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THE DEVELOPMENT OF GELATINE DRY PLATES

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THE DEVELOPMENT OF Gelatine · Dry · Plates

A Practical Manual for the Amateur.

BY

REV. W. H. BURBANK,

Author of "Photographic Printing Methods," "The Photographic Negative," Etc.

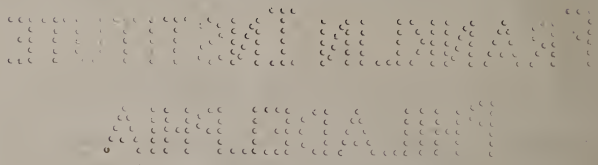
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PREFACE.

Of making books photographic there is seemingly no end, and he who is rash enough to add still another to the long list may well be asked his reasons for so doing.

In the present case it is hoped that a satisfactory answer will be found in the fact that there is at present no exhaustive treatment of the important question of development readily accessible to American amateurs.

The foundation of a good print is a good negative, and this is largely a matter of skillful development, the leading principles of which, as they have been taught me in my own practice, I have endeavored to explain in plain language in the following pages.

So far as possible I have aimed to give a reason for the formulas and methods recommended, and I have entered somewhat at length into the theory of development, in order that the amateur may be in a position to compound his developer intelligently and with reference to his special needs.

I have not sought to multiply formulas in the body of the book; I have merely taken a typical formula under each class and endeavored to make its method of action and its possible modifications so plain that he who runs may read.

To the great army of amateur photographers, many of whom are known to me personally, all of whom I would be glad to know, this attempt to make smooth the somewhat difficult path of development is most heartily dedicated by

THE AUTHOR.

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SPECIAL LITERATURE ON DEVELOPMENT.

Outside of current periodical literature, which is full of articles on the subject, the following special works have been consulted :

"Le Devéloppement de L'Image Latente." By A. De La Baume Pluvinel : Paris, 1889. Gauthier-Villars et Fils.

"Traité Pratique du Devéloppement." By Albert Londe : Paris, 1889. Gauthier-Villars et Fils.

"Development." By Lyonel Clark : London, 1890. Hazell, Watson & Viney.

"The Chemistry of Photography." By Raphael Meldola : New York and London, 1889. Macmillan & Co.

To the first and last of these, special obligations are due for information regarding the chemical reactions of development.

CHAPTER I.

GENERAL PRINCIPLES.

THE LATENT IMAGE.—The sensitive surfaces which we have to consider in the following pages are formed by coating glass, paper, or other suitable substance with a viscous solution of gelatine, holding in suspension bromide of silver in a more or less finely divided state, according to the degree of rapidity of the emulsion. When such surfaces are exposed to light, either in the camera or under a negative, the sensitive compound undergoes a change of some kind, the exact nature of which is not definitely known, and which is invisible until the application of certain reagents, called developers, which possess the property of making the image visible. The bromide of silver is decomposed wherever it has been affected by the action of light, and a dark deposit of silver is formed on those parts, in exact proportion to the intensity of the light-action.

This action of light is called latent or actinic, and the invisible image is a latent image, since it can be made visible by the application of suitable reagents.

THE NATURE OF THE LATENT IMAGE. — Photographic scientists are by no means in agreement respecting the exact nature of the image formed by the action of light on these gelatino-bromide surfaces. Two theories have been advanced in explanation of the change thus produced — the one chemical, and the other physical. According to the chemical theory the image produced by a short exposure to

light is of precisely the same nature as that produced by a prolonged exposure, that is, it is a partial or complete decomposition of the bromide of silver, which is reduced to a sub-bromide. If the action of light has been sufficiently energetic the number of molecules thus reduced is numerous enough to produce a visible image. In the case of exposures of brief duration the reduced molecules are too few in number to produce a visible image, and a latent image is the result.

According to the dynamic or physical theory, the luminous rays produce a change of molecular condition, destroying the equilibrium previously existing, thus producing a new molecular arrangement, which is amenable to the action of the developer. The reduced or changed molecules are still molecules of bromide of silver, only in a modified condition.

Owing to the fact that the direct demonstration of the nature of the change is at present quite beyond the reach of even the most refined chemical methods, it is impossible to give an authoritative statement regarding the correctness of either of the above theories, but inability to determine the exact nature of the latent image does not, fortunately, seriously affect the conditions of development. We know that a change of some kind is produced, and that the effects of this change may be made visible and permanent by the use of suitable reagents. How best to do this is the sole object of the following pages.

The Possibility and Theory of Development.—Here, again, positive statement is not permitted. If the dynamic theory be accepted, it seems probable that the tendency of the action of light upon the molecules of silver bromide is to separate them and thus weaken the bonds of union between them. The molecules thus separated may be

regarded as possessed of a certain degree of potential energy, by which they are enabled to exercise a greater attraction over surrounding bodies than is exercised by those molecules which are more intimately combined. If an exposed plate is covered with a reagent containing silver in a condition of easy precipitation, the metal is attracted by the molecules of the film, which have been acted on by light, and is deposited only on those parts of the film which have received a light impression, and in exact proportion to the intensity of that impression. The image is thus built up by accretion, and the developers which act in this way are known as physical developers. This is the usual method of development for collodion plates.

Instead, however, of precipitating the silver on the surface of the exposed film, it can be subjected to the action of a reagent which has a reducing power over the modified molecules of silver bromide. In this case the molecules of the reagent are attracted only by the modified molecules of the film, and the decomposition of the latter takes place only in those parts which have been impressed by light. In this case the coloration of the film is more in the nature of a stain than a deposit, as in the former case. Developers which act in this way are called chemical developers, and the method is that employed in the development of gelatino-bromide plates, and is, therefore, the subject of this book.

Before leaving this preliminary treatment of the subject, it should be said that the modified bromide of silver can be completely reduced only by reagents which are able to continue the separation of the bromine from the silver begun by the action of light. In other words, the developer must be a reducing substance. Such substances are found among those bodies which have a strong oxidizing power. But all

easily oxidizable substances are not equally well adapted to the development of the latent image. Many are too powerful to be used for this purpose, even when well restrained. When the action of the developing agent is too powerful, we have a general reduction of silver over the entire surface of the plate, producing the phenomenon familiarly known as fog.

CHAPTER II.

THE DEVELOPING ROOM.

ALTHOUGH the discussion of the construction and arrangement of the developing room is not entirely germane to the subject-matter of the present book, a brief discussion of the subject does not seem wholly out of place in view of the important part which the developing room plays in development. I have purposely discarded the use of the time-honored expression, "Dark Room," as being a misnomer. We do not want dark rooms when we develop our plates. We want rooms abundantly lighted with light of a safe quality. I am not a believer in the charms of an imperfectly lighted developing room in which the chances of success are appreciably diminished by inability to determine the condition of things in the developing tray at a glance. I prefer to have an abundance of light and to provide my trays with covers of stout cardboard or wood, removing them at brief intervals to examine the plate.

It is obviously impossible to give any hard and fast details for the construction of the developing room. Individual needs and tastes differ so much that what would suit one would be of no value for another. In general it may be said that the room should be of fair size. Ten by fourteen feet is none too large if much serious work is to be done in the room. If possible, it is well to have another room connected with the developing room by double doors, for such photographic operations as do not require seclu-

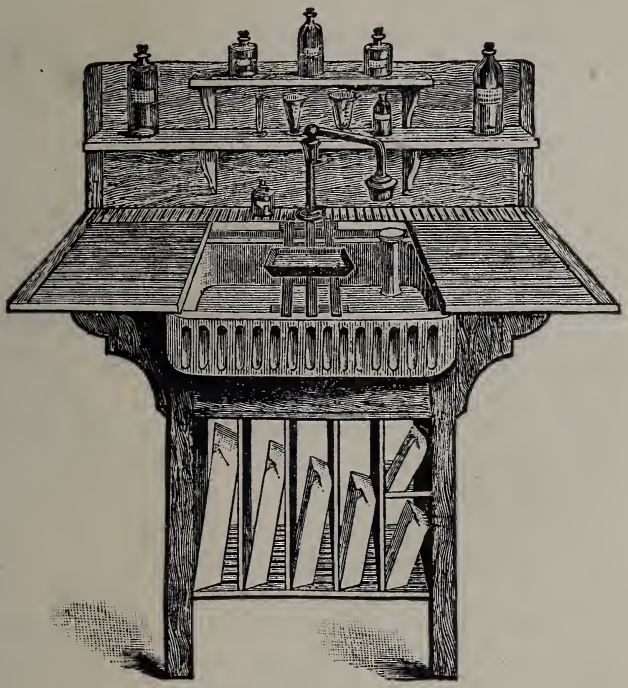
sion from daylight. If this room be fitted up with the usual appliances of a laboratory, including a sink and running water, the amateur is well equipped for serious experimental work, which should form a part of the education of every lover of the science.

The developing room proper should be provided with double doors in order that one may go in and out without fear of injury to the sensitive surface.

The Lighting.—I very much prefer artificial light to daylight, for the reason that it is more constant and more easily controlled. Whenever possible the source of light should be placed outside the room, to avoid heat and the products of combustion. In this case a large opening is cut in the wall immediately over the sink. At least three sliding frames should be fitted to the opening, one glazed with plain ground glass, another with ruby glass, and the third with yellow glass. If orthochromatic work is to be attempted, a fourth frame, covered with stout brown paper, should be added. With this arrangement the operator has perfect control over the quality and intensity of the light, both of which may instantly be adapted to suit the work in hand.

The Sink.—A lead-lined wooden sink is preferable to one of iron or earthen ware, as there is less danger of breaking a plate or graduate which may be carelessly dropped. It will be found advantageous to provide two swinging water-taps, one fitted with a fine rose and the other with a plain open nozzle. The sink should be of good size and preferably provided with a bottom sloping from the sides to the lowest point in the middle. It should be fitted with a sliding rack on which to place the developing tray. At the right should be placed the hypo tank or tray in a position to be free from all chance of contaminat-

ing other chemicals. Shelves may be arranged on either side of the window over the sink to suit individual tastes. Beneath the sink suitable racks for trays should be arranged. Fig. 1 gives a suggestion for the construction of a very convenient and serviceable sink.



DEVELOPING SINK. FIG. 1.

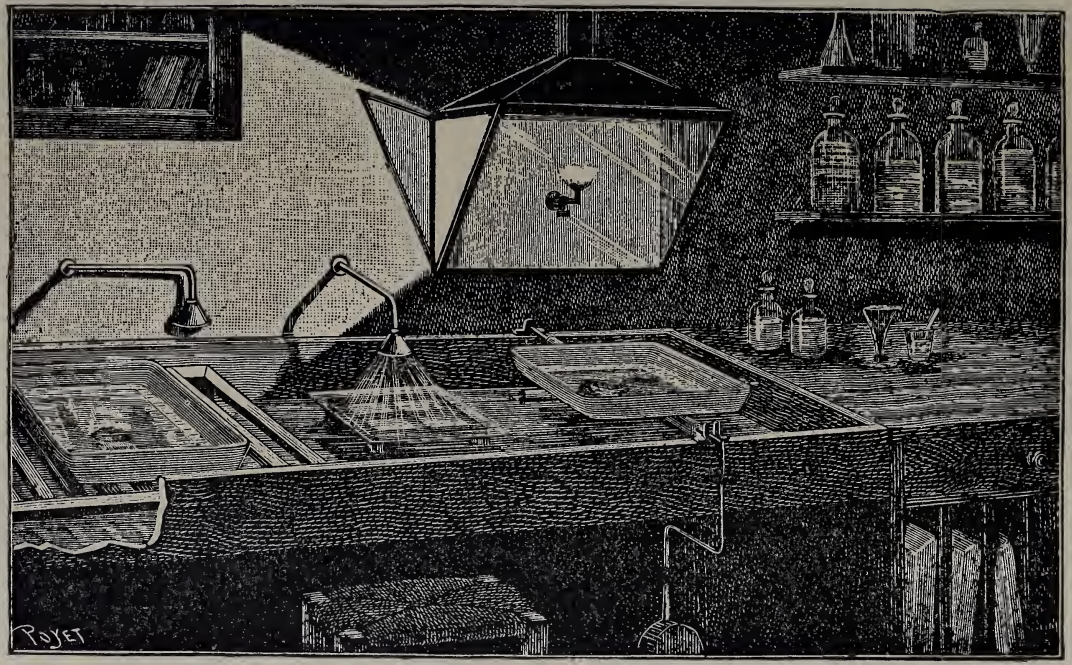
The other fittings of the room, such as shelves, drawers, tables, etc., are best left to the fancy of each worker. Efficient and light-tight means of ventilation should be provided and the question of heating must not be neg-

lected. Fig. 2, which is reproduced from M. Londe's book on Development, shows a very effective arrangement of developmental accessories. On the right of the sink is seen a very simple rocking arrangement, which will be found a great convenience in cases of prolonged development.

Of course, it is understood that successful development is not conditioned by the possession of such elaborate facilities as are described. Good work is possible in any darkened room with a water jug and a waste-water pail for accessories, but these are only make-shifts, and have no place in this discussion.

A Portable Developing Room.— Figures 3 to 6 show the details of construction of an easily constructed developing room which combines the advantages of convenience and portability. It can be taken down or put together in a short time, and it is recommended to those amateurs to whom the first of May brings new quarters, or who do not care to go to the trouble or expense of building a permanent abiding place for the Lares and Penates of development. The cuts are taken and the description is abridged from the pages of *Der Amateur Photograph.*

Fig. 3 is a perspective view of the room showing the method of construction. A number of light frames of wood covered with stout pasteboard or sheathing paper, forms the sides, ends and top of the structure, which may be placed in a convenient corner of any available room. One of the frames contains a smaller frame mounted on hinges to form the door. As to size, a room 6 feet long, 4½ feet wide and 7 feet high, is as small as will afford the necessary working space. The width is governed by the width of the work table and the space to be left between



DEVELOPING ROOM. Fig. 2.

it and the side of the room. In joining the frames the following precautions must be taken to insure light-tight joints: All joints must be reinforced by strips of thin wood screwed on both sides. Fig. 4 shows the method of protecting the joints on the two sides. Fig. 5 shows the method of protecting the corners, and Fig. 6, the same principle applied to the top or roof. The door must fit snugly against battens fastened to the inside of the frame. Any places where white light creeps in are easily made safe by pasting black paper over them. In order to prevent the light from coming around the bottom edge, it is well to screw half-inch cleats to the floor where this is admissible, and to screw the bottoms of the frames tightly against these.

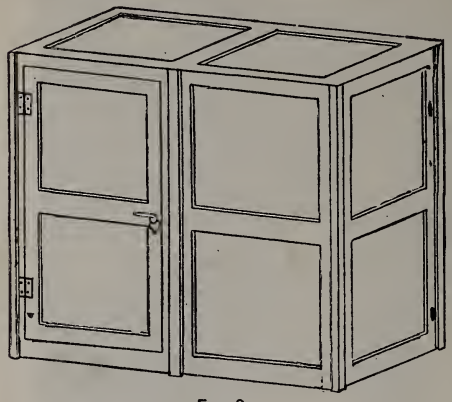


FIG. 3.



FIG. 5.



FIG. 4.

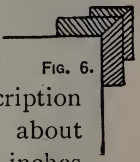


FIG. 6.

Fig. 7 shows a very convenient work table for such a room as this. Its construction is so plainly shown that extended description is unnecessary. The dimensions should be about three feet high, three feet long and eighteen inches wide. That portion where development is carried on may be covered with sheet lead with the edges turned

up about half an inch and provided with a waste-pipe leading to a pail underneath, as shown. The fixing bath is kept in a tray on the shelf under the top of the table. This shelf also holds the washing tray. Other conveniences may be added as need may arise, and the room will be found a very decided improvement over the out-of-the-way, inconvenient closets which serve so many for developing rooms.

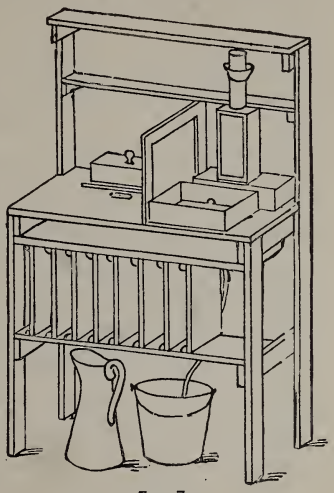


Fig. 7.

I have intentionally omitted all mention of trays, graduates, bottles, and the other impedimenta of the well-stocked developing room. Individual needs and circumstances vary so that no exhaustive list can be given. All these things have a way of accumulating of themselves as one's photographic horizon broadens, and their acquisition may be left to the purse and necessities of the worker, aided by the few hints which I have aimed to give in this chapter.

CHAPTER III.

THE PRINCIPLES OF DEVELOPMENT—THE TENTATIVE METHOD.

BEFORE entering upon the more practical part of the subject, it will be well to give what I conceive to be the underlying principles which govern all good development, and since in doing so I shall run counter to the advice of some good authorities, I desire to state that I believe the principles which I shall advance to be susceptible of proof by actual experience in the developing room. They are given as the result of careful study of the conditions which seem to me to govern all successful development of the latent image.

My experience has taught me that something more is required for the proper development of the latent image than the possession of a good formula and the ability to compound it; that there are laws of development which must be known and followed before the operator can hope to approach development intelligently. These laws constitute what we may term the philosophy of development. As the end of development is the production of a negative which will yield a print of a desired quality, the first step is the knowledge and appreciation of the qualities which the various printing processes, now commonly employed, demand in a negative. There is no question here of sharpness of outline or artistic quality. These are taken for granted.

Detail and intensity must be placed first among the neces-

sary qualities of a good negative. There must be no large patches of blank shadow, and the density must be proportioned to the printing process likely to be used in making the final print.

By far the larger portion of the subjects which are sought to be reproduced by means of photography are those in which there is an infinite gradation of tone from high light to intense shadow. Theoretically, the perfect negative is obtainable only under the condition of giving to each portion of the subject an exposure proportionate to the rapidity of its action on the sensitive film. But this is evidently an impossibility. What the photographer actually does in practice is to give an equal exposure to objects unequally lighted, thus introducing special difficulties in the later operation of development.

Those parts of the subject which are most strongly illuminated act with greater energy on the sensitive film than those less strongly lighted, and do so, probably, in direct proportion to the degree of the illumination. Hence, when the developer is applied, the high lights, as they are called, that is, those portions of the view which were most strongly illuminated, appear first, and are followed by the less intensely lighted portions, and these, in turn, by the darker parts, thus giving the tone gradation which is so marked a characteristic of a good negative.

If a proper exposure be had the details are obtained by continuing the development until these are well out in the deepest shadows. Save in exceptional cases, no part of the negative should be devoid of a certain amount of detail. From this we may deduce the first general rule or principle governing development :

The development must be continued until all the detail is visible

in the clear or white portions of the negative, which correspond to the shadows of the subject.

We may best study the question of intensity by distinguishing between local and general intensity. The former being the direct result of the unequal lighting of the subject, it reproduces the difference of tone gradation. It is determined by the intensity of the rays of light reflected from the different parts of the view, and it is generally independent of the operator, who, however, has it in his power to modify slightly the final result.

General intensity is the degree of density which must be given a negative in order to obtain good positives from it. There must be a certain degree of obstruction to the free passage of light through different portions of the negative.

It is quite possible for a negative to have detail and local intensity without being a good printer, for the reason that it lacks general or printing density. This may be too weak, in which case the print will be monotonous and tame, or it may be too strong, giving only harsh prints. The remedy in the first case is intensification, in the second reduction, neither of which, if properly conducted, affects the local or artistic intensity, for if it did, successful intensification and reduction would be impossible.

In addition to the rendering of detail, then, the operator must seek to give his negatives the degree of printing density best suited to his favorite printing process, since the different printing methods require negatives of varying density — the carbon process requiring thin and harmonious negatives, the albumen process those of medium density, and the platinum process those of greater strength.

Nothing is more detrimental to successful development than the belief that detail and density can be secured simul-

taneously. This is the weakness of all one-solution developers, that they are based on the false assumption that detail and density go hand in hand. Only in the case of negatives of feeble contrasts and proper exposure do the rendering of detail and the acquirement of printing density hold an equal place. But how often are these conditions realized? Not once in a hundred exposures. When the negatives present strong contrasts, and the time of exposure has been more or less wrong, as it usually is, the application of the developer reveals the difficulty of obtaining detail and printing density at one and the same time. The high lights, which are the first to appear, continue steadily to gain in intensity, and long before the details in the shadows are well out, the density of the high lights has passed the proper degree. Such a negative will give harsh prints in which the contrasts are exaggerated. The proper method of development in such cases is to hold back the density until the details are well out, by developing for detail first.

In the opposite case, where we have to deal with exposures on subjects feebly lighted and devoid of contrasts, the development must be for density first, if we would avoid foggy and weak negatives. This gives us our second rule or principle of development.

If these principles are well founded, it follows that a knowledge of the best methods of obtaining both density and detail is essential to anything like true development. These methods will be discussed later on. As a step in this direction, I propose now to discuss briefly the conditions outside of the developing room, which have much to do in determining both detail and density.

First on the list I place the influence of the plate itself.

It is far from being a matter of indifference whether we use slow or rapid plates. No manufacturer of sensitive plates will care to dispute the assertion that the quality and speed of the plate affect, even if they do not determine, the finished result.

With the slower grade of plates printing density is a matter of comparative ease. It is in the rendering of detail that the difficulty begins. With rapid plates the conditions are reversed. Detail is easily rendered, but printing density does not always accompany this rendering.

Slow plates have a tendency to increase contrasts unless the time of exposure is purposely prolonged to avoid this difficulty. Rapid plates tend to diminish contrast and so to produce more evenly lighted prints.

For the beginner there is nothing better than plates of medium density, since they have not the same tendency to fogging which is noticeable in rapid plates, always remembering that with slow plates the time of exposure should be lengthened to avoid excessive contrast, while with rapid plates the time of exposure should be made as short as possible, to avoid fog.

Another important element in the character of the negative and consequently of the print, is the nature of the objects to be reproduced. Careful study of the view to be photographed is essential to success.

M. Londe's division of the different photographic subjects is so true and helpful that I make no apology for reproducing it. The division is threefold :

First — Subjects which have a perfect harmony of tone gradation.

Secondly — Subjects which present strong contrasts and oppositions.

Thirdly — Subjects which have not enough of contrast and opposition, and are, consequently, weak.

Now, it is very evident that the same method of exposure and development cannot be adopted in all these cases, that some modifications are necessary in order to bring out the very best of which the view is capable.

It is a fact established by observation that if light is allowed to act upon a sensitive surface the effects of the light-action increase up to a certain point, and that beyond this point the intensity gradually diminishes, the light seeming to destroy the effects of its own work.

The law of reduction is this: The intensity of reduction is directly proportional to the length of time during which the addition of light has been continued, up to a certain point, which for any given plate may be called its fogging point. Beyond this point the effect is inversely as the action of light.

In practice, then, we obtain an increasing degree of intensity by lengthening the time of exposure, so long as we keep within the limit where the inverse action begins.

It is easy to see the importance of this principle, since the knowledge of it practically applied enables us to modify at will the results of an exposure.

With subjects of the first class the time of exposure should be as nearly correct as it is possible to make it. Subjects of the second class should be somewhat over exposed, both in order to secure the detail in the dimly lighted portions and to reduce the density of the high lights. Subjects of the third class require a brief exposure in order to increase the contrasts.

The reader who has followed me intelligently thus far is prepared to profit by the succeeding remarks on the general

principles of development, which are here given only after a thorough test of their value in the developing and printing rooms.

As the pyro developer is more flexible than any other in common use I have taken it as the standard of judgment, but the principles are equally applicable to all forms of developers.

In the development of an exposed plate either of two methods, the automatic and the tentative, may be adopted. I use the expression automatic development with reference to that method in which the plate is left in a ready mixed solution without any modifications being made to suit the seeming exigencies of the case. All one solution developers, as well as those in which a given formula is blindly followed, come under this head. I have a well-founded distrust and lack of confidence in the method of automatic development, which is rapidly becoming popular with amateurs of a certain class, whose one aim seems to be to reduce photography to a mere mechanical routine.

The tentative method of development, which I believe to be the only rational and philosophical method, is based upon the wise and intelligent adaptation of means to ends.

Starting with a thorough knowledge of the leading features of the view on the plate, and a perfect understanding of the effects to be produced, the various ingredients of the developer are to be so proportioned as to lead up to the desired result. From time to time as need arises various modifications are made. "Festina lente" is the motto of this method. A wise caution is exercised at the outset, constant vigilance is maintained till the end of the development, and a wise intelligence recognizes and meets all the exigences of the case as they present themselves.

I would lay it down as an axiom seldom to be deviated from that all development should begin slowly with a developer relatively weak in both accelerator and reducer. In this way the image will not surprise one by a sudden appearance and an equally sudden disappearance in a veil of fog. So far from beginning with a bath of maximum or even normal energy I would advise a bath of minimum strength save in those special cases, to be mentioned later, where a different method is absolutely necessary. In this way the operator remains an easy master of the development.

Several methods of reducing the strength of the developer are open to the operator. He may either diminish the quantity of the components of the solution, or dilute it with water, or finally add a trace of bromide. It is by no means a matter of indifference which of these methods is adopted, since each modification produces a different effect.

The diminution of the quantity of the accelerator and reducer is valuable chiefly because it allows a wider range of subsequent modification to suit special needs.

The addition of bromide retards the development and tends to increase contrast. Hence, its use is indicated for negatives of evenly lighted subjects where all possible contrast is sought. When the developer is diluted with water the development proceeds slowly, because the constituents of the solution are not present in sufficient quantities to produce a rapid reduction. The tendency of a diluted bath is to produce softness, and it should be employed in cases of known over-exposure when softness is desired.

If the development was begun with a bath weak in alkali and reducer, and it is desired to bring out the details before giving printing density, as is usually the case, successive small additions of the alkali are made until the

detail in the shadows is well out, then a final addition of pyro confers printing density.

As an example, let us take the case of a subject of strong contrasts which was intentionally over-exposed to diminish the contrasts. The proper method of development would be to begin with a small percentage of pyro and carbonate in the developer, adding the carbonate gradually in small quantities until the details are well out in the shadows. If the development were stopped at this point we should have a negative full of detail and of good local density, but lacking in general or printing density. This is gained by adding pyro until the general density is judged to be sufficient.

If the whole amount of pyro ultimately employed had been present in the solution from the start, the result would have been a negative in which density had been reached before the details were all out, the contrasts would be too strong, and it would present the appearance of an under-exposed plate.

If the view belongs to the third class, that is, if it lacks contrast and opposition, density must be given before the details are entirely brought out, by the addition of the carbonate in smaller quantities and the use of pyro to confer density.

This is the only rational method of development, and the fact that it requires intelligence on the part of the operator should be an argument in its favor with those who regard photography as something more than a press-the-button, one-solution sort of business. It is the only method which gives the operator an easy mastery of his negative and enables him to produce effects of various kinds. It is, I have reason to believe, the method of the masters in photography.

CHAPTER IV.

THE AUTOMATIC METHOD—THE USE OF BROMIDE OVER-EXPOSURE.

AUTOMATISM in photography has followed the advent of the dry plate and the discovery of methods of combining the elements of a developer in one solution of good keeping qualities. To make automatic photography more easy, ingenious cameras have been devised which do away with focussing, time exposures and most of the routine of the older school. I am as ready as any one to recognize the value of the new photography for many purposes, but I must protest against its being taken for all there is to photography.

Similarly, I do not deny that one solution developers have a certain value, but I maintain that they cannot produce the highest results.

The reign of automatic developers may be said to have begun with the general introduction of hydrochinon as a developing agent. It was found to be much easier to make a stable solution with hydrochinon than with pyro, and as it unquestionably simplified the process of development, much enthusiasm was manifested by its advocates. In another chapter I have tried to state the hydrochinon case as fairly as possible. Here I wish to say a few words about automatic development, meaning by this expression the development of a negative without any of the modifications mentioned in Chapter III. Theoretically the time of exposure is not an element of importance with this method.

All the operator is required to do is to place the exposed plate in this magical one-solution developer, take an occasional look at it and remove it when it is done, just as the cook removes the Thanksgiving turkey from the oven.

For every subject there is a time of exposure which we may call normal, the time that is required for all the details to impress themselves on the plate. Corresponding to this normal exposure there is, we may suppose, a normal developer, that is a developer which in a certain time will produce a negative rich in detail and of the proper general density. Now, if it were possible to determine the exact normal exposure for every subject, automatic development would become a possibility. In other words, it would be possible to develop every negative in a developer of the same constitution and in the same time. The exposure having been normal, the development would be normal as well.

But the moment the normal time of exposure is exceeded or not reached that moment the normal developer beomes practically useless. For every length of exposure there is a developer which will give the best results. What this developer is, can only be determined by adopting the tentative method of development. The negative may belong to any one of the three classes mentioned in the last chapter, requiring special treatment which cannot be applied in the automatic method.

I have no hesitation in saying that it is almost an impossibility to produce two negatives of precisely the same quality in any one-solution developer. Although no visible change may take place in the solution, either through use or age a change is produced nevertheless, which affects the result.

If any one doubts this assertion, he has only to make, say, three exposures on the same subject under similar conditions of light, exposure and plate. Let one of these exposures be developed for a given time in any one-solution developer. Let the other exposures be put away in a safe place, and at the end of two varying periods of time let them be developed in the same solution for the same length of time. Unless my experience is greatly at fault, a marked difference will be noticeable in the three negatives — a difference which can come from no other cause than a chemical change in the developer, the possibility of which is sufficient to condemn the one-solution developer for the highest grade of work. One other reason is sufficient to condemn the use of single solution developers. Most of these solutions are purchased from dealers and the buyer has no knowledge of their composition. He cannot therefore modify them intelligently and he thus places himself at the mercy of his developer.

The use of Bromide.—As bromide is naturally a retarder of development, at first sight it might seem that the proper corrective of over-exposure would be the addition of bromide in a quantity proportionate to the degree of the over-exposure. A more philosophical way of stating the principle governing the use of bromide, would be to say that the amount of bromide must be proportional to the intensity of the action produced by light.

This is the general law, but, like most other laws, it has its exceptions. In negatives of harsh contrasts where the time of exposure has been purposely exaggerated, the use of bromide is interdicted, since it would produce the very effect we are seeking to avoid. We then use a minimum of bromide and a diluted solution.

The use of bromide is recommended for negatives of poorly lighted subjects in order to heighten the contrasts.

There seems to be very little choice among the two bromides commonly used. The bromide of potassium is a more stable compound than the corresponding ammonium salt, and its use is therefore advised. Bromide of sodium is also a good restrainer. The bromides of zinc and copper seem to work best with the eikonogen developer.

Intentional Over-Exposure.—There are occasions when a judicious lengthening of the exposure will improve the quality of the negative, but the method is hardly to be recommended to the beginner, and in any event it is to be used with extreme caution, and preferably with slow plates. In spite of frequent statements to the contrary, I maintain, and am prepared to prove the statement, that with intelligently-conducted development, the time of exposure within reasonable limits, is not the all-important matter it is said to be. The statement which I make is, that the proper time of exposure may be increased without producing injurious results.

Every one is aware that there exists for each class of subjects, with a plate of a given rapidity, a time of exposure which we may call the time of normal exposure, since it is the time the plate must be exposed in order to render all the detail combined with good general density.

Now, if this normal time is diminished, some of the details will be lacking. If it is exceeded, the details will be all impressed, but there will be danger of fog through over-exposure. It is plain that what light has not effected, no developer, however powerful, can make visible. Hence, an under-exposed plate cannot be developed into a satisfactory negative.

It has already been shown that an over-exposed plate can be satisfactorily developed, either by the use of bromide or by a diluted or weak developer. Hence, it would seem to follow that the safest plan would be to over-expose and to modify the developer accordingly, and this is what I commonly do in my own practice, and what I recommend to others; only one must know his subject and his plate.

By adopting the tenative method of development, I find no difficulty in making good negatives on plates which have received at least double the normal exposure, and as this increase in exposure makes me sure of the details, I have long used it, except in special cases where for reasons already given a short exposure is called for.

CHAPTER V.

THE COMPONENTS OF THE DEVELOPER AND THEIR ADJUSTMENT.

THE method of alkaline development is undoubtedly the one which admits of the widest range of modification to suit the ever-varying conditions which present themselves in the developing room. In all alkaline developers there are three elements : 1, pyrogallol, or its equivalent ; 2, an alkali ; 3, a bromide.

The solution of the problem of development will be materially aided by a consideration of the function which each of these elements is called upon to fulfil and their relation to each other.

Pyrogallol, or its equivalent, is a powerful absorbent of oxygen and a reducer of the modified bromide of silver. Hence, it is the reducing or developing agent. The intensity or density of the deposit is largely conditioned by the quantity of the reducing agent present in the developer. Hence, additional density is conferred by an increased amount of pyrogallol or its equivalent. By judiciously proportioning the amount of the oxidizing agent, almost any degree of density may be given to a negative. To some extent the same effect is produced by increasing the affinity of the reducer for oxygen by increasing the quantity of alkali, or by decreasing it by the addition of a soluble bromide. It is not, however, a matter of indifference which of these methods of controlling density is adopted. An increase in the quantity of alkali increases the danger of fog by pro-

ducing an undue rapidity in the reduction process. An excess of bromide so diminishes the action of the reducer as to make the bringing out of fine detail difficult, if not impossible. It will be seen, therefore, that the developer must be compounded with a modicum of brains in order to obtain the best results.

There must be a proper balance between the ingredients of the developer, or partial or total failure will be the only result.

The problem which has to be solved with every plate is to bring out all the detail possible and at the same time to obtain good general or printing density, and this without the slightest trace of veil or fog.

The alkali aids in the attainment of detail by increasing the affinity of the reducer for oxygen, and the bromide has a strong tendency to diminish the chance of fog by slowing the reducing action. It is probable that the restraining power of the bromide is due to its tendency to form a double salt with bromide of silver, this double salt being more stable than the silver bromide and therefore less easily reducible.

If the reducing agent were always used in a dry state, that is, if for purposes of convenience it were not desirable to make up a stock solution to be drawn from as need arose, no other elements would be needed than those just mentioned. Since, however, a stock solution is often a necessity, it has been found necessary to add various substances to the solution of pyrogallol to prevent its rapid deterioration by oxidization. Of these substances the sulphite and meta-bisulphite of soda, meta-bisulphite of ammonium, formic, citric and other acids have been used with good results. The best of these is probably the meta-bisulphite of soda or ammonium, either of which will preserve a solution of pyrogallol for a moderate length of time.

The objection to the use of sulphite of soda is its tendency to pass over into sulphate of soda, which is a powerful restrainer.

My own custom is not to employ a stock solution, but to add the reducing agent in a dry state to the developer, thus dispensing entirely with the use of a preservative, which seems to me to be a needless if not an injurious complication. The simpler we keep our formulas the greater our chances of success.

MODIFICATIONS.—With alkaline developers containing pyrogallol a very wide range of modification to suit varying needs is possible. The normal proportions of the components of the developer may be taken to be nearly as follows: Pyrogallol, 0.5 parts; alkali, 2 to 6 parts; sulphite, 3 parts; bromide, 0.5 parts; water, 100 parts; or for each ounce of developer, 3 grains of pyrogallol; alkali, 10 to 30 grains; sulphite, 14 grains; bromide, 3 grains.

These proportions, however, may be changed to suit special circumstances. It is time now to speak of some of the more important of these modifications, and I shall treat the subject with reference to the pyrogallol developer, since this is the one most commonly employed.

As I have already said, I am an advocate of a moderately slow development, and strongly deprecate the use of a bath at its maximum of energy to begin development with. It is much safer in every way, especially in all cases where one is in doubt whether the exposure has been correct or not, to begin with a solution at its minimum energy.

Several methods of reducing the energy of the developer are possible. The quantity of the elements of the solution may be diminished, the bath itself may be diluted with water, or bromide may be added. Which of these methods

is to be employed in each case of known over-exposure will depend upon the character of the subject and the effect which it is desired to produce.

The addition of bromide retards the action, but at the same time tends to increase contrast and give density. The dilution of the bath equally retards the action but has no tendency to increase contrast or produce excessive density.

The use of bromide is indicated for the development of subjects uniformly lighted and presenting no strong contrasts, in order to heighten the contrasts. On the other hand, if the view was strongly lighted and presented great opposition, which it is desired to diminish as far as possible, the normal bath should be diluted with water. If the subject was well illuminated and the contrasts well balanced and harmonious, the development should be begun in a bath weak in pyro and alkali, developing first for detail and lastly for density. This result is obtained by adding successive small doses of the alkali at intervals until the details in the shadows are well out and then obtaining the density by a final addition of the necessary amount of pyrogallol.

With subjects of feeble contrast the method should be reversed. Here the aim should be to retard as much as possible the appearance of the details by a wise caution in the addition of the alkali, and to gain the greatest possible density by adding sufficient pyrogallol to accentuate as much as possible the feeble values of the subject.

Density.— One of the greatest difficulties connected with development for the beginner is to know the exact moment when the process of development should be stopped, that is, when sufficient printing density has been obtained. Of the many negatives which I have examined, including many of my own, there have been few which were removed from the

developer at just the right moment. Either they were taken from the bath too soon and lack printing density, or they were allowed to remain too long in the developer, and are over-dense to give the best results in the printing frame.

It is not an easy matter, even for the most expert, to determine in the light of the developing room the exact moment when the proper degree of density has been reached. Indeed, I am not certain that it is not largely a matter of intuition, gained only by long practice and not to be learned from written words. Still some hints may be given which may help a stumbling brother along the difficult road of development.

In general terms, it is best to allow the developer to act until those parts of the plate which have been feebly impressed, that is, those which remain white longest, begin to darken. With certain brands of plates, which lose strength in the fixing bath, it is safe to prolong the development until the edges of the plate which were protected from the action of light by the ledges of the slides show a slight veiling. If a plate be examined at this stage by reflected light, it will show a uniform dark tint. Examined by transmitted light the image will appear over-vigorous and the finer details somewhat clogged up. With some plates it is even necessary to allow the developer to act until the image seems to have disappeared entirely. A properly developed plate should show the image feebly on the back. A generally safe rule is to develop until the blacks and the strongest half-tones are plainly visible at the back of the plate, but much depends on the character of the plate and the method by which the prints are to be made. A properly exposed and normally developed plate should be finished within five minutes.

CHAPTER VI.

THE FERROUS-OXALATE DEVELOPER.

CHEMICAL REACTIONS. — When a sensitive surface which has been exposed to light is placed in a solution of ferrous-oxalate, the following reactions take place :

The ferrous-oxalate decomposes the water, changes into ferric-oxalate and ferric-oxide, while the hydrogen of the water is set at liberty.

$$6(C^2O^4Fe) + 3H^2O = 2[(C^2O^4)^3Fe^2] + Fe^2O^26H.$$
$$6(FeO,C^2O^3) + 3HO = 2(Fe^2O^3,3C^2O^3) + Fe^2O^3 + 3H.$$

The hydrogen, thus set at liberty, acts upon the modified bromide which it reduces :

$$AgBr + H = Ag + HBr.$$

The hydrobromic acid, formed by this reaction, acts upon the ferric-oxide of the previous reaction and produces ferric-bromide and water :

$$6HBr + Fe^2O^3 = Fe^2Br^6 + 3H^2O.$$
$$3HBr + Fe^2O^3 = Fe^2Br^3 + 3HO.$$

Adding these three equalities, we have as the final chemical expression of the reaction :

$$6(C^2O^4Fe) + 6AgBr = 2[(C^2O^4)^3Fe^2] + 6Ag + Fe^2Br^6,$$
$$6(FeO,C^2O^3) + 3AgBr = 2(Fe^2O^3,3C^2O^3) + 3Ag + Fe^2Br^3.$$

The modified bromide of silver is decomposed by the ferrous-oxalate, the reduced silver forms the lights of the

image, and there remain in the bath ferric-oxalate and ferric-bromide.

Preparation of the Developer.—The developer consists of a solution of ferrous-oxalate. This salt is formed when a ferrous salt is added to a solution containing an oxalate or oxalic acid. If a solution of neutral potassic oxalate is added to a solution of ferrous sulphate the liquid becomes red, grows muddy, and deposits yellow crystals of ferrous-oxalate, which is nearly insoluble in water, but readily soluble in warm solutions of the neutral oxalates of potassium or sodium. It is in combination with solutions of these salts that the ferrous-oxalate is employed as a developing reagent. Its best solvent is a saturated solution of neutral potassic oxalate. 100 parts of this solution dissolve 12 parts of ferrous oxalate. A saturated solution of potassic oxalate contains 1 part of the salt to 3 of water. In order to prepare 100 parts of the developer, 33 parts of neutral potassic oxalate are dissolved in 100 parts of water, and 12 parts of ferrous oxalate are added to the warm solution.

The more usual method of preparing the developer is to form the ferrous salt and dissolve it at the same time. This is easily done by adding one part of a saturated solution of sulphate of iron to three parts of a saturated solution of neutral potassic oxalate. In this case the potassic salt plays a double part : One part forms the ferrous oxalate, while the other part acts as the solvent.

As the proportions of oxalate and sulphate are determined by the solubility of the salts, they cannot be increased in order to strengthen the developing action. If an excess of the sulphate is added, a precipitate of ferrous oxalate is thrown down and the bath loses its reducing

power. It is important also that the potassic oxalate be neutral. An acid sample will not give clear images.

If the water employed to dissolve the potassic salt contains sulphate of chalk, a slight trace of oxalate of chalk is formed and the solution is not clear. As soon as the solution cools, however, the chalk will deposit and the clear liquid may then be decanted off for use in compounding the developer. To avoid the precipitate, distilled rain or melted ice water should be used.

The mixed developer does not keep well without the addition of some substance capable of reconverting the ferric sulphate to the corresponding ferrous salt. Tartaric acid has this property, and old solutions may be restored to activity by adding a trace of the acid and standing the bottle in the sun. The tartaric acid is oxidized at the expense of the ferric sulphate, which returns to the ferrous state.

We are now prepared to give a definite formula for the preparation of the developer, and the following has given me uniformly good results :

A.	Neutral oxalate of potash, ...	30 parts.
	Water, ...	100 parts.
B.	Sulphate of iron, ...	30 parts.
	Tartaric acid, ...	0.5 parts.
	Water, ...	100 parts.

This solution will keep indefinitely if placed in the sunlight when not in use :

C.	Bromide of potassium, ...	1 part.
	Water, ...	10 parts.

This is the restrainer, and is to be used only in case of over-exposure, or with very rapid plates to diminish the danger of veiling.

Development of Plates Normally Exposed. — When the exposure has been correctly timed, the percentage of one to three should be diminished. My own practice is to add one part of solution B to ten parts of A. If the high lights begin to appear in one or two minutes, the exposure has been about correct, and the plate is transferred to a tray containing one part of A to four of B, and the development is completed in this stronger developer. If for any reason exceptional density is desired, a few drops of C should be added. In any case the action of the developer is to be continued until the image seems to have disappeared and is quite plainly visible at the back of the plate.

Development of Under-exposed Plates. — If a three or four minutes' treatment with the one to ten solution produces no visible effects, the plate should be treated for under-exposure. For this purpose it is transferred to a tray containing the strong one to three solution. If this does not produce the desired effect within a few moments, the plate was probably too slightly acted upon by light to make successful development possible, there being too slight an amount of modified bromide present in the film for the developer to act upon. Something may possibly be effected by the addition of a drop or two of a 1 to 2.000 solution of hyposulphite of soda, itself a powerful reducer. This addition is always attended with danger, owing to its strong tendency to produce fog.

Development of Over-exposed Plates. — If the image comes up quickly and evenly in the one to ten solution, the plate must be treated for over-exposure by removing it at once to a dish containing one part of solution C to ten parts of water. A few drops of C are then

added to the developer and the plate returned to it. Unless the time of exposure was greatly exaggerated, the image will develop gradually and strongly in this modified developer. It is always best, however, to have a quantity of old developer at hand for use with over-exposed plates. Many skillful operators recommend the addition of one part of old developer to three of freshly mixed for the development of landscape views, and the method has its advantages.

CHAPTER VII.

THE PYROGALLOL DEVELOPER.

CHEMICAL REACTIONS.—Pyrogallol, or pyrogallic acid, ($C^6H^6O^3$,$C^{12}H^6O^6$) is a white powder extracted from gall nuts or by treating gallic acid. It dissolves in 2.5 its weight of water, and is readily soluble in alcohol and ether.

When exposed to atmospheric influences its solutions rapidly oxidize, absorbing oxygen from the air with the formation of certain obscure brown products and such acids as oxalic, acetic and carbonic, according to the following formula :

$$C^6H^6O^3 + 7O = C^2H^2O^4 + C^2H^4O^2 + 2CO^2,$$
$$C^{12}H^6O^6 + 14O = C^4H^2O^8 + C^4H^4O^4 + 4CO^2.$$

The addition of an alkali to a solution of pyrogallol greatly increases its avidity for oxygen, and in consequence its reducing power on the salts of silver. A plain solution of pyrogallol will develop an exposed plate but only with great slowness. Its action is hastened by the addition of an alkali which quickens the development by acting upon the acids arising from the oxidation of the pyrogallol, and by combining with the hydrobromic acid produced by the decomposition of water. A bromide of the alkali is thus formed in the developer.

The following formula expresses the complex reaction :

$$C^6H^6O^3 + 2AgBr + 2AzH^3 + H^2O = (C^6H^6O^3 + O) + 2Ag + 2AzH^4Br,$$
$$C^{12}H^6O^6 + AgBr + AzH^3 + HO = (C^{12}H^6O^6 + O) + Ag + AzH^4Br.$$

This formula expresses the reactions which take place when an exposed plate is developed in a solution of pyrogallol with ammonia as the alkali.

Preparation of the Bath.—The pyrogallol developer must consist of the acid and an alkali. This alkali may be either ammonia, potash, or soda either as carbonates or sulphites. In England, ammonia has been the alkali most commonly used. In America, soda or potash, or both combined, are usually preferred.

The action of these alkalis is not the same. Ammonia is probably stronger in detail giving power, and produces better modeled negatives, but its use is attended with greater danger of fog. Carbonate of potash seems to have more power over the rendering of detail than the corresponding salt of soda, while the latter is a better density giver. With either of these salts there is less danger of fog than with ammonia, but they have a more decided tendency to frill the plate. On the whole, however, my personal preference is for a developer containing both the carbonates of potash and soda, with sufficient sulphite of soda added to insure a clean development.

A normal developer with ammonia is compounded as follows :

Water, ...	100 parts.
Pyrogallol, ...	0.3 parts.
Ammonia, ...	0.5 parts.
Bromide of potassium, ...	0.5 parts.

The proportion of ammonia may safely be increased to three parts, but it should not exceed this. The amount of pyro may be doubled or trebled if necessary to obtain density.

The following may be taken as a normal potassic carbonate developer :

Water,	100 parts.
Pyrogallol,	0.5 parts.
Carbonate of potassium,	0.5 parts.

The amount of carbonate may safely be increased to five parts, if necessary, and the amount of pyrogallol to two or three parts.

A normal soda developer is given in the following formula:

Water,	100 parts.
Carbonate of sodium,	1 to 5 parts.
Pyrogallol,	0.4 parts.

A good combined soda and potash formula is as follows:

Water,	100 parts.
Pyrogallol,	0.5 parts.
Carbonate of soda,	2 parts.
Carbonate of potash,	1 part.

PRESERVATIVES.—The baths prepared as above discolor rapidly during development, and the plate becomes more or less tinged with yellow. In the case of thin negatives this yellowishness is an advantage, since it has a tendency to increase contrast, but most operators prefer to avoid it so far as possible, or to remove it after fixing. The latter is attained by placing the negative in a bath of dilute sulphuric acid containing a little alum to counteract the frilling effect of the acid.

The discoloring of the bath is due to oxidation, which is, in turn, caused by the reduction of the silver salt and by the absorption of oxygen from the air. This process of oxidation may be greatly retarded by the addition of some

substance which has greater affinity for oxygen than the pyrogallol. Such substances are sulphite of soda, the meta-bisulphites of soda and ammonium and many others of similar nature. Either of these three salts will produce the desired result by absorbing oxygen from the air and leaving the pyrogallol free to deal with the modified silver salt. Until recently sulphite of soda has been almost exclusively employed, but lately the meta-bisulphites have been used with better results.

The proportion of preservative may vary from three parts to one hundred to much larger quantities. A typical formula of this class is:

Water, ...	100 parts.
Pyrogallol, ...	0.5 parts.
Carbonate of potash, ...	1 part.
Sulphite of soda, ...	3 parts.

If a little sulphuric acid is added to the solution it will unite with the sulphite of soda to form sulphurous acid, which is a powerful deoxidizer.

Sulphite of soda, either in crystals or in solution, easily passes over into sulphate of soda, which is not a preservative, but which has strong restraining qualities. In order to test the purity of a given sample of sulphite, it is treated with hydrochloric acid. The sulphurous acid is set free and chloride of sodium is formed. When the sulphite is entirely decomposed, chloride of barium is added to the solution. If any sulphate is present, a large quantity of a white precipitate is formed.

Sulphite of Soda as a Developer.—Apart from its preservative action, sulphite of soda has a certain power of development. It can develop the latent image without the

addition of any other alkali. The development is slow, but the image is very pure and bright. For very much over-exposed plates sulphite of soda has a value which is not at present properly recognized.

For other formulas the reader is referred to the tables at the end of the book.

The developing solution is conveniently compounded by adding to three ounces of water 6 grains of dry pyrogallol, 12 to 30 grains of carbonate of potash and 10 to 20 grains of sulphite of soda, according to the plate and the exposure.

Development of a Normally Exposed Plate.—My own method of development is to make up 1 to 10 solution of the carbonate and sulphite.

For a 5 x 8 plate three ounces of water are placed in the tray, six to ten grains of dry pyrogallol and half an ounce of the sulphite solution are added. When the pyrogallol is dissolved, the plate is immersed in the tray, and at the end of half a minute the developer is poured off into a graduate and one dram of the solution of the carbonate is added. This is allowed time to act. If the high lights do not show themselves within one or two minutes, another addition of carbonate is made, the tray being constantly rocked to insure equal action. The image will soon show itself under this treatment and it will probably gain in detail and density until the process is complete. If, however, the details in shadows are slow in appearing, more carbonate is added. If good general density is not obtained more pyrogallol is added, and in some cases a few drops of a one to ten potassic bromide solution. In any case the development is continued until the image is plainly visible at the back of the plate.

Development of Under-Exposed Plates.— If the plate after a prolonged immersion in the above bath shows a general want of vigor and detail, it has been under-exposed, and the bath must be modified in order to meet the conditions of the case. In order to understand the nature of these modifications, a thorough knowledge of the action of each of the components of the bath is necessary. This knowledge I now propose to impart to the best of my ability.

The alkali has a double function; one portion is used in neutralizing the acids which are formed in the bath and thus accelerates the action. The amount of alkali taken up by this action varies according to the quantity of pyrogallol present. The remaining portion of the alkali remains free in the bath and acts directly upon the plate. The tendency of the alkalis is to transform the bromide of silver into the modified state. Hence, the alkali which is free to act upon the plate modifies that portion of the bromide which has been feebly impressed by light, and tends to bring it into the same molecular state as the bromide which has received a more energetic light-impression. Hence, the alkali acts as an accelerator and diminishes contrast.

If a large amount of pyrogallol is added the bath becomes more concentrated and the development more rapid. But at the same time the amount of free alkali is diminished and its action on the bromide of silver is lessened. Hence, the increased addition of pyrogallol to the bath is equivalent to diminishing the amount of alkali, and has the further effect of increasing contrast.

From this somewhat abstruse reasoning, which seemed to be necessary to a complete understanding of the subject, we may easily deduce the best course to follow in the

development of under-exposed plates. If the plate has a tendency to fog, the quantity of alkali must be diminished, otherwise the plate will probably veil over and nothing but a monotonous image be developed. Hence the proportion of alkali to pyrogallol must be diminished. The development will proceed slowly but the image will acquire the requisite density, which it would not have done had the opposite course been taken.

If the plate is a good fog resister, as is the case with most slow plates, and the contrasts are harsh, the alkali must be increased and the pyrogallol diminished. The alkali has a tendency to veil the plate and so to produce soft images. When the details are well out, the development is completed by the addition of pyrogallol to give sufficient density.

Contrast may also be diminished by allowing the developer to remain at rest during the development. This is due to the fact that the developer rapidly loses its energy where it is in contact with the heavy shadows which have been most strongly impressed, and retains it longest where it is in contact with the half-tone, since here it does not so soon become saturated. But this method can be adopted only when the bath has been considerably diluted. A strong bath would in this case produce markings.

Development of Over-Exposed Plates.— When a plate has been over-exposed the contrasts are diminished and the likelihood of fog increased. For both these reasons it is necessary to begin the development with a small amount of alkali and an excess of pyrogallol. Bromide of potassium may also be added, and should be so added to the normal developer when the image flashes up at once on the application of the bath.

CHAPTER VIII.

THE HYDROCHINON DEVELOPER.

HYDROCHINON or quinole is an aniline derivative prepared by oxidizing aniline sulphate with potassic bichromate. Its chemical symbol is $C^6H^6O^2$, and owing to its powerful reducing power and its comparative freedom from fog and stain, it has gained many friends and is now quite generally employed. Chief among the many advantages claimed for the quinole developer are: simplicity and ease of working; the great latitude of exposure allowed; absence of fog and stain; clear glass in the shadows; suitability for bromide paper work.

On the other hand the developer has a strong tendency to give harsh negatives, full of excessive contrast. It often produces yellow fog or stain, and it is extremely slow in action.

On the whole, after careful experiments with quinol, I have found it decidedly inferior to pyrogallol in the majority of cases. Still it has some excellent qualities, and I would recommend the amateur to master its method of working as a help to the solution of difficult problems in the developing room. Many a negative which shows lack of general density under the action of the pyrogallol developer may be brought up to the printing point by the application of an old quinol solution.

I have been most successful with the formulæ and method of preparation recommended by the Paris Photo-

graphic Club, which is as follows : Boil one quart of distilled or ice water and divide equally into two quart bottles ; while still warm, add to one of the bottles 250 grains of sulphite of soda in crystals, to the other add 500 grains of sodic carbonate in crystals, both salts having been previously powdered. Shake well until dissolved. To the sulphite solution add 150 grains of quinol and shake until dissolved, then add 8 to 10 drops of glacial acetic acid. When the two solutions are cold the quinol solution is poured rapidly into the carbonate, and the mixture is then filtered. The mixed solution forms a powerful developer which keeps well and works satisfactorily. For time exposures, it should be diluted one-half with water, or equal parts of new and old developer may be used to advantage.

Another good formula is the following:

Quinol,	15 grains.
Citric acid,	7 "
Sodium sulphite,	60 "
Water to make	3½ ounces.

The caustic alkalis are often used when a more speedy action is desired. The best method of using them seems to be the addition of about 5% of a 40% solution of caustic potash just before development.

Mr. Henry J. Newton recommends the following formula:

Water,	1 ounce.
Caustic soda,	4 grains.
Sulphite of soda,	30 "
Hydrochinone,	3 "

This forms a good developer for instantaneous expo-

sures : for time exposures, the strength should be reduced from one-half to one-third with water.

Good results can be obtained on nearly all brands of dry plates with any of the above formulæ, but I have found that certain makes of plates do not take kindly to quinol, quickly veiling over.

As a rule, it will be found advisable to add a trace of bromide of potassium to the bath, and to follow the general method of development recommended for pyrogallol. Development will be begun with a weak bath and its energy will be gradually increased, if necessary, by the gradual addition of the alkali to bring out detail.

The bath should be used at its maximum strength only in cases of known under exposure. The best results are obtained by the judicious use of a new and an old bath. The longer the exposure, the greater the proportion of the old bath ; short exposures require a smaller percentage of old bath. Where strong contrasts are desired, an old bath is to be used. For soft, harmonious effects the quantity of new bath should be increased.

Although the same solution can undoubtedly be used to develop a number of negatives in succession, it must not be forgotten that the bath loses its strength with use. With each plate developed the composition of the bath changes and it works more slowly and with greater contrast. If a number of negatives are to be developed in the same solution, it is best to begin with a weak bath and to develop the negatives in the order of their times of exposure, beginning with that which received the shortest exposure. It will also be found necessary, now and then, to strengthen the bath by the addition of more alkali. This same method is also recommended for other forms of developer.

When the development has been unduly prolonged, the negative often shows a yellow stain. This may be removed by the application of Farmer's ferricyanide and hypo reducer which will be found under the formulæ for reducing agents.

On the whole, I cannot recommend the quinol developer as in any way superior or even equal to pyrogallol. It has all the deficiencies of the latter and is devoid of many of its good qualities. I am convinced that more detail can usually be obtained and better printing negatives made with pyrogallol than with quinol.

For negatives where great purity in the lines is necessary, as in the case of reproductions and slides, quinol undoubtedly possesses some advantages, but for landscapes this same excess of transparency produces harshness in the prints.

CHAPTER IX.

THE EIKONOGEN AND PYROCATECHIN DEVELOPERS.

EIKONOGEN is an aniline derivative of great reducing power which has recently come into general use as a developing agent, owing as much perhaps to judicious and persistent advertising as to its intrinsic merits, which, though great, are not overwhelmingly superior to those of pyrogallol. About the same claims are made for the new reagent as for quinol. It works rapidly, has no pronounced tendency to produce fog or stain, keeps fairly well in solution, and is strong in power to bring out detail. Its great weakness is a varying degree of solubility with different samples and a tendency to give thin negatives.

I have not found that a solution of eikonogen keeps appreciably better than a properly prepared pyrogallol solution, but as I always use both reagents dry, I do not consider this an important point. Eikonogen certainly does bring out detail more rapidly than other developers, but in the end I have not usually found a greater amount of detail in a negative developed with it and one of the same subject, similarly exposed, developed with pyrogallol. Some operators have claimed that it was not an uncommon experience with them to develop a negative with eikonogen and fix it while another was developing in a pyrogallol bath, but my experience does not bear out this statement.

But this is not to say that eikonogen is not a most excellent developer. I am now using it largely in preference to

pyrogallol on account of its general freedom from liability to fog or stain the negative. It gives as clear negatives as quinol with much less of harshness and excessive contrast, and it possesses remarkable staying powers. I have developed as many as twenty 5 x 8 negatives in the same solution with no appreciable lengthening of development or change in the quality of the negatives.

My favorite formula and method of working are as follows :

A.	Water, ...	1 ounce.
	Sulphite of Soda, ...	40 grains.
	Eikonogen, ...	20 "

Dissolve in the order given. With some samples of eikonogen it will be found impossible to dissolve the above amount, but this seems to make no appreciable difference. The water should be distilled and hot.

B.	Distilled water, ...	1 ounce.
	Carbonate of potash, ...	50 grains.
	Sulphite of sodium, ...	50 "

In both solutions the crystallized sulphate is used. These are strong solutions and are to be mixed in equal parts for short exposures. For time exposures the mixed developer should be judiciously diluted with water, the greater the proportion of water the softer the negative.

Solution A will retain its good qualities for several weeks if pure chemicals and distilled water are used.

My own practice is to dissolve the proper amounts of sulphite and eikonogen in distilled water immediately before using.

If the image flashes up immediately on the application of the developer, the negative is quickly transferred to a tray containing 4 grains of bromide of potash, 1 dram of glycerine and 10 ounces of water, which is allowed to act for two or three minutes, after which the plate is returned to the developer.

If no trace of an image appears within two or three minutes, two or three drops of a 10-grain solution of caustic soda may be added.

If the developer as above compounded works too rapidly the amount of water in solutions A and B should be doubled.

Another equally good formula is that recommended for use with the Cramer plate, but which I have found to work well with most other makes.

A.	Distilled water, ...	10 ounces.
	Sulphite of soda (crystals), ...	240 grains.
	Eikonogen, ...	120 "
B.	Water, ...	10 ounces.
	Carbonate of potassium, ...	1 ounce.
C.	Water, ...	10 ounces.
	Bromide of potassium, ...	1 ounce.

NORMAL DEVELOPER.

Solution A, ...	3 ounces.
" B, ...	1 ounce.
" C, ...	6 to 12 drops.

A mixture of old and new developer is recommended for general work.

Soft, harmonious negatives are produced by the addition of water.

To sum up the case in favor of eikonogen, it may be said that while the extravagant claims of the introducers of the

new reagent have not been confirmed by careful experiment, it is a valuable addition to the list of photographic chemicals. It is probable also that further experiments may give an increased ability to work the salt to better advantage. As a developer for instantaneous exposures, I regard it as greatly superior to either pyrogallol or hydrochinone, bringing out all possible detail and giving good general density if it is given time to act. The negatives are, as a rule, perfectly free from fog or stain and of a good printing color.

The Pyrocatechin Developer.—Pyrocatechin, $C^6H^4(OH^2)$, although recommended as a developer by Dr. Eder as long ago as 1880, has never come into general use, in spite of its many excellent qualities, on account of its high price.

In conjunction with carbonate of potash it is a quick acting and powerful developer, giving clear negatives of a beautiful brown tone.

The solution quickly turns a deep brown and does not keep well. The following formula has given good results in my hands :

A.	Water, ...	40 parts.
	Sulphite of soda, ...	4 parts.
	Pyrocatechin, ...	1 part.
B.	Water, ...	40 parts.
	Carbonate of soda, ...	1 part.

Normal developer: Equal parts of A and B. Restrain, if necessary, with bromide of potassium.

If the cost of the salt can be reduced, it will undoubtedly assume a prominent place among the developers of the future.

CHAPTER X.

DEVELOPMENT OF INSTANTANEOUS EXPOSURES, FILMS AND LANTERN SLIDES.

INSTANTANEOUS EXPOSURES.—The problem to be solved in the development of plates which have been but feebly impressed by light is to obtain all the details that can be forced out without producing an undue degree of density. At the outset it may be stated that no developer will bring out on a plate details which the action of light has not first impressed upon the sensitive surface. The details must be present potentially or they can not be made visible by the action of the developer.

Authorities are divided on the question as to whether a weak or a strong developer should be used for instantaneous work. M. Londe recommends a concentrated solution, strong in reducer and accelerator, with a trace of bromide added and a smaller quantity of water than is used for the normal developer, and advises a rapid development. I have done good work by this method, but many makes of plates will not stand forcing at the outset. A safer plan is to begin with a weakened developer, giving the plate a preliminary soaking for two or three minutes in a dilute alkaline solution made by diluting the usual ten per cent. stock solution with twice its bulk of water.

It is important that the details be obtained before sufficient printing density is had, and the preliminary alkaline treatment helps towards this. A very safe method is to

keep the alkaline and reducing solutions in separate trays, changing the plate from one to the other as may be necessary. In this way the operator has more control of the process and is better able to treat his subject intelligently. As a general rule it is safe to say that the alkaline treatment should predominate at the beginning at least, and that density should be sought for only well towards the end of development.

Any of the formulæ already given will serve the present purpose, bearing in mind the special directions given for the treatment of under-exposed plates. Above all things avoid being in a hurry. It may take an hour to develop a shutter exposure, but I am seldom longer than twenty minutes about it. The development must be carried further than with longer exposures. Quick plates feebly light-impressed lose much of their density in the fixing bath. The image should show strongly on the back.

The eikonogen developer seems to possess a better capacity for rounding out an instantaneous exposure than either pyro or hydrochinon, and there is less likelihood of stain.

Development of Films.—Very little need be said on the development of the film negatives which seem likely to play an important part in the photography of the future. They are coated with the same emulsion used on glass, and the only modifications are those made necessary by the uncomfortable tendency of the films to curl up in the bath, a difficulty more apparent with the thin Eastman film than with those which have a thicker base of celluloid. In the case of the former I have found it a fairly good plan to soak the film for a short time in clean water to which a slight trace of glycerine has been added, or to add a modicum of glycerine to the developer. The use of glycerine is not, how-

ever, to be advised indiscriminately. In damp weather it will not be needed, and on the whole it is better to endure the ills of curled films than to make use of a substance likely to complicate the drying.

Any developer that will work satisfactorily with films on glass will work equally well with celluloid films. After fixing and washing, the films should be pinned by the corners to boards in order that the tendency to curl may be diminished. If after drying, they curl badly, they should be wound tightly about a round stick with the films out and left for an hour or two to straighten.

So far as my experience extends, the greatest difficulty with thin films at least comes in the printing frames, when the heat of the sun is apt to aggravate the tendency to curl.

Development of Lantern Slides.— The prime essential to a thoroughly good slide is sufficient clearness in the high lights to allow most of the light to pass through, and not sufficient density in the shadows to offer too great an obstruction to the passage of the light. Most slides made by amateurs err in both these particulars. They are too dense in the shadows and too transparent in the lights. Absolutely clear glass is not what is wanted in the perfect slide, but just the degree of depth of deposit which will give atmosphere to the projected image. I am speaking now of slides of natural scenery. For buildings, reproductions of drawings, plans, etc., the shadows should be dense and the lights transparent. But the snow effect so often seen in slides with summer foliage, owing to the excessive clearness of the high lights is neither pleasing nor truthful. I do not believe that the perfect slide can be made on the gelatine dry plate, and I would strongly advise all amateurs who

"go in" largely for slide making to book themselves up in the wet collodion or tannin processes, either of which are vastly more economical and give better results than the best gelatine lantern slide plates. But as I know that few will take this trouble, I give one or two formulæ which I have found to be reliable. But before doing, I wish to say a word about the exposure. Whether made by contact printing or by reduction in the camera, a full exposure should be given if the best results are desired. A lantern slide which has been forced in development to bring out details which should have come out easily, is rarely such as one would care to exhibit. In order to give clean effects it is usually advisable to add a considerable proportion of bromide to the developer, and this addition necessitates a full exposure, which must not, however, be prolonged to the fogging point.

The ferrous-oxalate developer has long been a favorite with dry-plate slide makers, on account of its simplicity and cleanliness.

Those who like strong and vigorous blacks will find the following formula a good one:

A.	Oxalate of potash,	8 ounces.
	Water,	30 "
	Citric acid,	60 grains.
B.	Sulphate of iron,	4 ounces.
	Sulphuric acid,	8 drops.
	Water,	32 ounces.

For the developer add 1 ounce of B to 3 of A, and ½ ounce of water, and 5 to 10 drops of the usual bromide solution.

Allow development to proceed until the shadows are strong and the image visible on the back. Then wash and

fix. Wash for half an hour and immerse for five minutes in

Water,	36 ounces,
Pulverized alum,	3 "
Citric acid,	¼ ounce,

to harden the film and clear the image.

Hydrochinon, pyrogallol or eikonogen will give equally as good, if not better results. The following formulæ are known to be reliable :

HYDROCHINON.

A.	Sulphite of Soda (crystals),	400 grains,
	Water,	6 ounces,

dissolve and filter, and add

	Hydrochinon,	120 grains,
B.	Carbonate of potassium,	240 "
	Water,	6 ounces,

dissolve and filter.

DEVELOPER.— 1 ounce each of A and B, and 2 ounces of water. Bromide if needed to produce clean work.

EIKONOGEN.

A.	Sulphite of soda (crystals),	240 grains,
	Water,	8 ounces,

dissolve, filter, and add

	Eikonogen,	20 grains,
B.	Carbonate of potash,	32 "
	Water,	1 ounce.

DEVELOPER.— 2 ounces of A and 1 dram of B.

PYROGALLOL.

A.	Carbonate of soda (crystals), ...	1 ounce.
	Water, ...	8 "
B.	Sulphite of soda (crystals), ...	1 "
	Water, ...	8 "
	Pyrogallol, ...	2 drams.

DEVELOPER.— Equal parts of A and B. Restrain with bromide if necessary.

The development of lantern slides should be continued until the image is clear and distinct and seemingly more dense than is necessary, but for clean work it is essential that the development be stopped as soon as the edges of the plate show signs of darkening, or even before. Otherwise the high lights will be too strongly veiled. Cleanliness is another essential point. It is best to have a separate set of trays for developing slides. The hypo solution should be freshly mixed, and for slides it need not be stronger than 1 to 10. The acid fixing bath is to be recommended.

CHAPTER XI.

FIXING AND WASHING.

FIXING. — The process of fixing is necessary in order to dissolve out all the unreduced silver which is still sensitive to light, and therefore a cause of fading or darkening if the unfixed plate be exposed to the action of light.

After development, the film contains both metallic silver and unaltered bromide of silver ; both of these salts must be removed by a suitable solvent in order to render the negative transparent and permanent. The salt most commonly employed for this purpose is the hyposulphite or thiosulphite of sodium. When a negative is immersed in a solution of this salt a double hyposulphite of silver and sodium is formed. The first is readily soluble both in a solution of hypo and in water, while the second is insoluble in water and only slowly soluble in hypo solutions. Hence, the necessity for a prolonged immersion in the fixing bath to insure the complete solution of the salt, the presence of which in the negative would cause its speedy destruction. The negative should be left in the bath at least five minutes after the whitish color has disappeared.

The degree of concentration of the hypo solution is not of special importance, except so far as it affects the speed of the solving action. A dilute solution will fix, but only slowly. The proportion of one to five is about right. Until quite recently a plain hypo solution has been most commonly employed, the addition of alum to harden the film and

prevent frilling not being advisable on account of the danger of the formation of a sulphur compound. But within a short time acid solutions have been recommended, on account of the clearing and hardening action which such a solution has on the gelatine film and the greater permanency thus given to the bath. A solution of hyposulphite undergoes a change even when kept from atmospheric influences. Sulphur is deposited and sulphite of sodium formed. The presence of the latter salt is not injurious, since it is itself a fixing agent, but the presence of sulphur is likely to work injury to the negative.

One of the latest and best formulæ for the fixing bath is Cramer's, as follows :

Water,	1 quart,
Sulphite of soda (crystals)	4 ounces,

Dissolve, and add

Sulphuric acid	½ ounce,
Chrome alum (powdered),	3 ounces,

Dissolve and pour into a solution of

Hypo,	2 pounds,
Water,	3 quarts.

This bath remains clear even with frequent use; it does not discolor the film, and it has a hardening effect.

Another equally good bath is made by the addition of one ounce of acid-sulphite of sodium, a new chemical, to each pint of hypo solution. In this bath, which remains clear after long use, fixation is very rapid. The only precaution necessary is to keep the bath distinctly acid at all times by the occasional addition of fresh acid-sulphite solution.

I would strongly advise the use of a grooved tank or a triangular trough for the fixing bath in place of the time-honored tray, which allows all the impurities present in the bath to settle on the film to its detriment. In a tank the negatives stand up in the bath and the impurities do not attach themselves to the films. In a trough they are fixed with the films down.

Since the formation of the double insoluble hyposulphite is promoted by the action of light, the fixing should be done in the developing room, but extreme care must be taken to keep the fixing solution from the developing trays.

The number of plates which can safely be fixed in a single solution of hyposulphite has its limits. It is limited by the production of the double salt. Fifteen grains of bromide of silver require about seven grains of hyposulphite to form the double salt. The average whole plate contains not far from fifteen grains of bromide of silver, and seven grains of hyposulphite are required to form the double salt. If then we have twenty ounces of bath containing four ounces of hyposulphite, we can theoretically fix at least 220 whole plates in it. But since an excess of hyposulphite is necessary in order to dissolve the double salt it is not safe to fix more than half that number. The cost of the hyposulphite is low enough to warrant a little prodigality in its use.

In order to make sure of perfect fixation, the negative must be left in the fixing bath for some time after all whiteness has disappeared from the back. It is also advisable to place the plate for a short time in a second fixing bath freshly mixed.

Washing.— The elimination of the last traces of hypo from the film is a matter of no little difficulty. Unless the

fixing agent is entirely removed, the negative will soon be made useless for printing by the formation of the unstable hyposulphurous acid, which rapidly decomposes into sulphur and sulphurous acid, a decomposition which produces the yellowing of the film which is so frequently met with in negatives which have been printed from a few times. For rapid and thorough washing nothing is better than a grooved washing box and an abundance of running water. Two or three hours of this treatment will effectually remove the hypo. Where running water cannot be had the plates may be washed in a tray by frequently changing the water. Better than this is a wooden trough in which the negatives can be placed with the films down. The water must be frequently changed. Still another good method is to mount a wooden tank at the end of a slanting board of suitable length and width. A small short pipe is inserted at the bottom of the tank, and another longer piece is soldered at right angles to it. This pipe is closed at the ends and has a number of fine holes pierced along the front. The water is thus delivered in a fine spray. The negatives are placed on the board, the tank is filled with water, and an hour's washing will leave the films in good condition.

Hypo Eliminators.— Various compounds act as hypo eliminators by converting it into a salt which is easily washed away, or whose presence in the film is not injurious. They should be used, however, only after the larger portion of the hypo has been removed by washing. Alum and the hypochlorites have been recommended as hypo eliminators. The former, while unquestionably a hypo eliminator, produces a reaction by which sulphur is precipitated, and sulphur is nearly as difficult to eliminate as hypo itself.

The hypochlorites are free from this objection. Javelle water, a compound of hypochlorite and chloride of potassium, is a very good eliminator of hypo. The plate is immersed in a bath containing fifteen parts of Javelle water to one hundred parts of water, where it is allowed to remain for five minutes, after which it is washed for ten or fifteen minutes. The theory of the reaction is that the chlorine of the hypochlorite decomposes the water, forming hydrochloric acid and oxygen. The oxygen oxidizes the hyposulphite and converts it into bisulphate of potassium, a salt which, being readily soluble in water, is easily washed out.

Belitzsky's hypochlorite of zinc eliminator is, perhaps, better than Javelle water. This is made by dissolving 300 grains of chloride of lime in one quart of water, six hundred grains of zinc dissolved in twice its weight of water. The mixture is shaken and allowed to settle. The clear portion is decanted for use, one part being added to sixty parts of water to form the eliminator.

Test for Hypo.— If the operator wishes to make sure that the last traces of hypo have been removed, he must test the last wash water for traces of the salt. Iodide of starch forms a very delicate test for hypo.

This is prepared by dissolving a small quantity of starch in ten times its weight of water, and boiling until the solution be clear. A few drops of a saturated alcoholic solution of iodine are then added, which forms the blue iodide of starch. Two drops of this are sufficient to impart a bluish tinge to distilled water. But if any traces of hypo are present the blue will not appear.

On the Use of Alum.— Alum, owing to its hardening action on films of gelatine, has often been recommended as

a useful addition to the fixing bath to prevent frilling, but this addition is to be deprecated as of little value and liable to injure the film. The sulphate of aluminium contained in the alum forms with hypo a precipitate of alumnium and sulphur which is insoluble and detracts from the clearness of the negative. For this reason, I cannot advise the use of alum in connection with the fixing bath.

Another purpose for which alum has been recommended is to remove the yellow color sometimes produced by pyrogallol. This practice is not free from danger unless a vertical tank is used.

Most water contains carbonate of chalk, a substance which in connection with sulphate of aluminium forms carbonic acid, sulphate of chalk and the insoluble sub-sulphate of aluminium, which is precipitated on the film, bearing with it any impurities in suspension in the bath. In order to avoid this precipitation on the film, a vertical tank should be used.

The alum bath, properly used, has undoubtedly great value in promoting the preservation of the negative, by rendering the gelatine inert to the action of moisture. After a thorough removal of the hypo it is always well to immerse the plate for a short time in a saturated solution of alum and then to wash for a few moments.

Clearing Solution.— The yellow color due to the use of pyrogallol may be removed by immersing the plate, after fixing and washing, in the following solution:

Saturated solution of alum, ...	32 ounces.
Sulphuric acid, ...	$\frac{1}{2}$ ounce.

CHAPTER XII.

INTENSIFICATION AND REDUCTION.

INTENSIFICATION. — Occasionally, either by reason of under- or over-exposure, or from insufficient development, the negative lacks the necessary printing strength. The contrasts are too feeble to give strong prints.

This weakness may be overcome by the process known as intensification, which consists in substituting a more opaque deposit for the deposit of silver. By this means the high lights become more intense and the negative more vigorous. The possibility of successful intensification depends upon the fact that the intensifying solutions act upon the different parts of the negative in proportion to the amount of silver contained in them. The high lights, having a denser deposit of silver, are more strongly acted upon than the shadows where the silver deposit is less dense. In this way the contrasts are heightened.

Intensification may be partial or complete, local or general. Partial, when only a part of the reduced silver is acted upon; complete, when the intensifier is allowed to act until it has penetrated through the film; local, when only a part of the film is intensified; general, when the whole surface is acted on. Partial intensification is to be resorted to when the negative lacks only a slight degree of density; its effect is to increase the contrast between the half-tones without appreciably increasing the general contrast between the half-tones and the high lights. Complete intensification

is necessary for thin, monotonous negatives. The essential difference between partial and complete intensification is simply one of the length of time the intensifier is allowed to act.

It must be remembered that intensification does not produce detail; it simply heightens contrast and increases density. There is no more detail in a negative after intensification than before. The detail may be more distinctly visible owing to the greater strength imparted to it, but the detail must be in the negative before intensification.

Another point in connection with intensification is the necessity of a thorough elimination of the hypo before any attempt is made to strengthen the negative. If this point is not attended to the film will inevitably be stained.

One of the most common methods of intensification is a preliminary treatment with bichloride of mercury, followed by copious washing and a subsequent treatment of the modified silver with ammonia or sulphite of soda. In this case the mercuric chloride is converted into mercurous chloride by the loss of half its chloride which acts upon the silver of the film and converts it into chloride of silver. Both mercurous and argentic chlorids are colorless, hence the action of the bath whitens the film. After a thorough washing, the film is treated with a dilute solution of ammonia.

In this bath a double reaction takes place. The ammonia dissolves the chloride of silver and forms an ammonia-mercuric compound with the chloride of mercury. This compound is an intense black, and taking the place of the silver in the film, it acts as an intensifier.

The bichloride of mercury bath should be made by dissolving one part of the mercury in twenty parts of hot water.

The well washed plate is placed in a tray and covered with the solution. If partial intensification is all that is desired, the action of the bath is stopped before the film is whitened through to the glass. Where complete intensification is necessary, the film must be whitened through its entire thickness. After washing for fifteen minutes in running water, the plate is placed in a solution of ammonia diluted with twenty times its bulk of water. The film quickly blackens, and when the whiteness has entirely disappeared, it only remains to wash the plate thoroughly. The tray should be rocked to insure an even action.

If the negatives are thoroughly washed after fixing and after the mercury treatment, there is no reason to suspect the permanency of the intensified film.

A ten per cent. solution of sulphite of sodium may be substituted for the ammonia solution of the preceding formula, and in this case the washing after the mercury treatment need not be so thorough. The reaction is similar to the preceding, the sulphite dissolves the chloride of silver and reduces the mercurous chloride to the metallic state.

A modification of the above method is to treat the plate after whitening with mercury with the ferrous-oxalate developer. In this case both the chlorides of silver and mercury are reduced to the metallic state. If the negative is not sufficiently intense after this treatment, the film may be again whitened and the developer applied as before. Other methods of intensification will be found in the tables of formulæ.

Local Intensification.— It often happens that certain portions only of the negative are too thin to print well. This is most common with negatives containing deep

shadows when the time of exposure was not sufficient to bring out detail with the proper degree of density.

In this case, local intensification may be resorted to. The only absolutely certain method, in my experience, is the application, with a soft brush, of Hall's Intensifier to the parts to be intensified. This will strengthen the detail. To lighten up deep shadows and prevent them from printing too deeply, indigo blue moistened with gum water may be applied to the back of the negative with the finger.

In inexperienced hands intensification is rarely successful, in most cases producing spots and stains which ruin the negative. It is always better to make a new negative, if possible, or to over-develop and then reduce.

Reduction of Negatives.— There are two distinct cases in which it is advisable to reduce the density of a negative: 1, those cases in which the general density is so great as to make the negatives abnormally slow printers ; and, 2, those cases in which by reason of insufficient exposure, and consequent prolonged development to bring out detail, the contrasts are too strong and the density of the high lights too great.

In the first case it is necessary to dissolve a portion of the reduced silver without altering the tone gradation. In the second case only the high lights should be reduced, leaving the shadows unaffected. This may be called the method of local reduction, and is best effected by applying the reducer given below to the parts which it is desired to reduce with a soft brush.

Farmer's ferricyanide and hypo reducer is one of the most reliable. The negative is immersed for a few moments in a one to two hypo solution. A few drops of a one to ten solution of ferricyanide of potassium solution are added, and

the progress of the reduction carefully watched. If the action is not sufficiently rapid more of the ferricyanide may be added. When the negative has been sufficiently reduced, it must be thoroughly washed to reduce the hypo.

For local reduction, the mixed reducer is applied with a soft brush, but the operation demands great delicacy of touch.

Dr. Eder recommends a reduction method, which consists in converting the reduced silver into chloride of silver, and then reducing or reconverting the chloride into the metallic state. By this method the half tones may be brought into better balance with the high lights. The method is as follows:

The plate is immersed for a few moments in

Water, ...	1 ounce.
Bichloride of potassium, ...	5 grains.
Hydrochloric acid, ...	5 drops.

After washing, the image is redeveloped with ferrous-oxalate, then fixed and washed as usual.

In order to reduce a negative which has been made too intense by the mercury intensification, a dilute solution of cyanide of potassium may be used, but as this is a virulent poison the greatest care must be taken in its use.

CHAPTER XIII.

SUPPLEMENTARY NOTES.

SO MUCH of the quality of the negative depends upon its proper development, that I am not willing to leave the subject without a few additional remarks, which I trust may still further clarify the matter and help to make the development of a negative less a matter of chance and luck and more of scientific accuracy.

This also affords an opportunity of calling attention to a new ingredient of the developer which has been introduced into this country from Germany, and which my experiments have conclusively proven to be a valuable addition to Materia Photographica. This substance is a strong solution of the acid-sulphite of sodium which, formed in the solution when sulphite and an acid were added, acted as a preserver. But the quantity of acid-sulphite thus formed was exceedingly small as compared with the amount of sulphite present. The new solution contains fifty per cent. of acid-sulphite in solution, and twice the amount of the preserving element, sulphurous oxide, contained in ordinary sulphite of soda crystals. It comes in the form of a pale, yellowish liquid, with a strong smell of sulphurous oxide gas, with which it is saturated. The effect of its addition to the fixing bath is to hasten the action of the bath and to prevent its discoloration. Negatives fixed in this modified bath are remarkably clear and free from stain. Added to the developer the new reagent acts as a powerful preserver and diminishes the likelihood of stain or fog.

The proper proportions for the fixing bath are about one ounce of the acid-sulphite solution to every pint of bath, adding more as the bath loses its acid reaction.

For the pyro developer one drop of acid sulphite should be used for each grain of pyro; a trifle less is necessary for eikonogen. It does not seem to give good results with hydrochinone.

The following formulæ were recommended in Anthony's Bulletin, and have given me remarkably good results:

A.—Pyrogallol, ... 1 ounce.
Acid-sulphite, ... 1 ounce
Water, ... 10 ounces.
B —Carbonate of soda (crystals), . . 5 ounces.
Water, to make . . . . . 10 ounces.
Developer :—Water, 1 ounce ; A, ½ to 1 dram ; B, 1½ to 2 drams.
A.—Eikonogen (finely powdered), . . 1 dram.
Acid-sulphite, ... 1 dram.
Water, to make . . . . . 10 ounces.
Dissolve the eikonogen before adding the acid-sulphite.
B.—Carbonate of potassium (dry), . . 3 ounces.
Water, ... 10 ounces.
Developer :—A, 1 ounce ; B, 1 to 2 drams.

Lambert's Ammonia Developer.—In the British Journal Year Book for 1890, the Rev. F. C. Lambert gives a formula for an ammonia developer, with tabulated directions for its use, which is well worth reproducing here:

P.—Sulphite of soda, ... 1½ ounces.
Pyro, ... 1 ounce
Citric acid, ... 1 dram.
Water, to make . . . . . 6 ounces.
B.—Bromide of potassium, ... ½ ounce.
Water, ... 4 ounces.
A.—Ammonia (.880) . . . . . 1 ounce.
Water, to make . . . . . 4 ounces.

The table gives the approximate relative proportions of P. B. & A. in drops for four ounces of developer. The table is suggestive only, and must be modified to suit the plate, subject and conditions of exposure.

EXPOSURE.	SUBJECT.	P.	B.	A.
Under	Strong in contrast.	10–20	10–20	10–30
	Normal " "	30–40	10–20	30–40
	Weak " "	40–50	10–20	40–60
Medium	Strong in contrast.	30–60	30–60	30–60
	Normal " "	60	60	60
	Weak " "	60–90	60–90	30–60
Over	Strong in contrast.	60	60	10–20
	Normal " "	60–90	60–90	20–30
	Weak " "	90–120	90–120	20–30

The careful study of this and the following tables will teach the thoughtful experimenter many valuable lessons in development.

M. Londe has compiled the following useful tables on the modification of the developer :

MODIFICATIONS IN DEVELOPMENT

ACCORDING TO THE RESULT DESIRED.

Result Desired.	Exposure.	Modifications.	Method of Development.
Negative with strong contrasts.	Short.	Concentrated Bath.	Bromide. Rapid Development. Density, then Detail.
Soft, harmonious negative.	Prolonged.	Dilute Bath.	Trace of Bromide. Slow Development. Detail, then Density.

MODIFICATION OF THE DEVELOPER

MADE NECESSARY BY THE NATURE OF THE SUBJECT.

NATURE OF THE SUBJECT.	EXPOSURE.	MODIFICATIONS IN THE DEVELOPMENT.	MANAGEMENT OF THE DEVELOPMENT.	RESULT SOUGHT.
Normal. No strong contrasts.	Normal. Slight over-exposure.	Normal bath.	Trace of bromide. Slow development. Obtain detail first, then density.	Normal reproduction of the subject.
Strong contrasts.	Over-exposure in proportion to the amount of contrast.	Diminish the ingredients of the bath.	Trace of bromide. Very slow development. Detail first, then density.	To avoid harsh contrasts.
Monotonous.	Shorten the exposure.	Concentrated bath. Diminish the water.	Increase the bromide. Rapid development. Density first, then detail.	To increase contrast.
Instantaneous.		Concentrated bath. Diminish the water. Increase the ingredients.	Slight trace of bromide. Rapid development. Detail first, then density.	To gain both detail and density.

Development with Ammonia Vapors.— Dry plates may be developed by means of the vapor of ammonia. The plates are soaked for some time in a normal pyrogallol solution and then exposed to the ammonia vapor. This is best effected by pouring a dilute solution of ammonia into a tray and holding the plate, film down, a few inches above the tray. Care must be taken to avoid too strong a solution of ammonia, as it is liable to produce red and green fog. The greatest advantage of this method is its adaptability to the local development of those parts of the plate which show a lack of detail when developed by the usual method. For this purpose the ammonia should be kept in a bottle provided with a small tube. Those parts of the plate which it is desired to develop further are held over the tube until the details are out. In this way it is often possible to bring out detail in the shadows, but there is more or less of uncertainty about the process.

Development in Two Solutions.— Some operators advise the use of two solutions, one of the developer proper and the other of the alkali. If the plate has been over-exposed it is soaked for a short time in a solution of pyrogallol or other reducing agent, and afterwards transferred to a tray containing the alkali. This will bring out the details. If density is lacking the plate is again placed in the first tray. For under-exposures the process is reversed and the plate is placed in the alkali solution first.

Intentional Over-Exposure.— One of the safest rules for exposure is to give the plate as long an exposure as it will bear without fogging. By this means one is sure of detail, and in general a better balanced negative. Even with extremely rapid plates of good make considerable latitude of exposure is possible, if the necessary conditions of

development are understood and met. With a given development there is for each class of subjects a time of exposure which may be called normal, by which is meant an exposure which will give the best results with the given developer. But even with long practice it is far from easy to determine the exact time of this normal exposure. If the exposure has been too short, there will be a lack of detail in the finished negative. If an over-exposure has been given, there will be plenty of detail, but a lack of density, and perhaps fog.

There is no method by which details are brought out on a plate which has not received sufficient exposure to impress them on the sensitive surface, but it is possible, as has been shown, to modify the developer in such a way as to overcome the effects of over-exposure. For this reason it is always best to give as long an exposure as the plate will bear without fogging, and to modify the developer accordingly. In this way one is sure of the details in the shadows, and a little practice will give the necessary knowledge of the amount of over-exposure allowable with any special plate.

Local Development by Brushing.— A very effective method of local development is to apply strong solutions to the portions which it is desired to force by means of small camel's-hair brushes. The brush dipped in the alkali solution and applied to the plate will assist in bringing out detail which would otherwise be lacking. The reducing solution may be applied in the same way to confer density on parts which develop too thin.

The Influence of Temperature on Development.— Heat is a great promoter of chemical action. A cold developer will develop slowly and a warm one quickly, often

with lack of density. The proper temperature for the developer is between 60 and 70 degrees. This temperature should be maintained by the use of warm water in winter and ice in summer.

If a plate develops poorly in a solution at the above temperature, the addition of a little warm water will often help matters.

Saturated Solutions.— The use of saturated solutions is to be deprecated on account of the difficulty of obtaining a solution of standard strength. If a salt is dissolved to saturation in hot water a certain proportion of it will crystallize out when the water cools. In winter the strength of a saturated solution is less than in summer. The better plan is to dissolve a certain number of parts in a sufficient number of parts of water to keep the solution well within the saturation point. In this way one is always sure of having a solution of standard strength at any temperature.

FORMULAS.

DEVELOPERS.

BEACH'S.

A.	Warm distilled water, ...	2 ounces.
	Sulphite of soda (crystals), ...	2 ounces.

dissolve, and when cold add

	Sulphurous acid, ...	2 ounces.
	Pyrogallol, ...	½ ounce.
B. 1	Water, ...	4 ounces.
	Carbonate of potash, ...	3 ounces.
2	Water, ...	3 ounces.
	Sulphite of soda (crystals), ...	2 ounces.

1 and 2 are combined. For shutter exposures take 3 ounces of water, ½ ounce of A and 3 drams of B, increasing the latter to 5 drams if the image hangs back.

For over-exposures take 3 ounces of water, 3 drams of A and 1 dram of B, adding more if necessary. Bromide may be used to restrain.

PHOTO TIMES SODA DEVELOPER.

A.	Pyrogallol, ...	1 ounce.
	Sulphite of soda (crystals), ...	4 ounces.
	Sulphurous acid, ...	4 ounces.
	Water, ...	10 ounces.
B.	Carbonate of soda (crystals), ...	1 ounce.
	Sulphite of soda (crystals), ...	1½ drams.
	Water, ...	16 ounces.

Developer: 1 dram of A to 1 ounce of B. For under-exposures, increase the quantity of B; for over-exposures restrain with bromide of potassium 1 to 10.

PHOTO TIMES POTASH DEVELOPER.

A.	Pyrogallol,	1 ounce.
	Sulphite of soda (crystals),	4 ounces.
	Sulphurous acid,	4 ounces.
	Water,	10 ounces.
B.	Carbonate of potash,	3 ounces.
	Carbonate of soda (granular)	1 dram.
	Water,	10 ounces.

Developer: 1 ounce of water, 1 dram each of A and B. Accelerate with B. Restrain with bromide of potash 1 to 10.

CRAMER'S CARBONATE OF SODA DEVELOPER.

A.	Sulphite of sodium,	6 ounces.
	Carbonate of soda (crystals),	1½ ounces.
	Water,	64 ounces.
B.	Distilled water,	6 ounces.
	Sulphuric acid,	15 drops.
	Sulphite of soda (crystals)	1 dram.
	Pyrogallol,	1 ounce.

Developer: In cold weather take 8 ounces of A, and 2 to 5 drams of B. Keep at 70 degrees.

In summer take 6 ounces of water, 4 ounces of A and 2 to 4 drams of B. Keep at 60 degrees.

HARVARD PYRO DEVELOPER.

A.	Distilled water,	12 ounces.
	Sulphite of soda (crystals),	2 ounces.
	Citric acid,	60 grains.
	Bromide of ammonium,	25 grains.
	Pyrogallol,	1 ounce.

Dissolve separately, mix in order given and filter.

B.	Distilled water,	12 ounces.
	Sulphite of soda,	2 ounces.
	Carbonate of potash,	4 ounces.

Developer: A, 1 dram; B, 1 dram; water, 2 ounces. For detail, add more water; for contrast, increase the amount of A; for density use more of A and B. For instantaneous exposures use double the quantity of water to begin with. When development is partly completed, pour off the solution and finish with the normal developer.

EDER'S ONE SOLUTION PYRO DEVELOPER.

Sulphite of soda (crystals), ...	5 drams.
Carbonate of soda (crystals), ...	2½ drams.

Dissolve in 2 ounces of boiled distilled water, and when cool add forty-six grains of pyrogallol. Keep in well stoppered bottles, and dilute with five times the bulk of water for use.

CRAMER'S HYDROCHINON DEVELOPER.

A.	Sulphite of soda (crystals), ...	480 grains.
	Phosphate of soda, ...	160 grains.
	Water, ...	8 ounces.

Dissolve, filter, and add

	Hydrochinon, ...	100 grains.
B.	Carbonate of soda (crystals), . . .	480 grains.
	Phosphate of soda, ...	160 grains.
	Water, ...	8 ounces.

Developer. — Equal parts of A. and B.

CHAUTAUQUA HYDROCHINON DEVELOPER.

A.	Hydrochinon, ...	¼ ounce.
	Sulphite of soda (granular), . . .	1 ounce.
	Meta-bisulphite of potassium, . . .	30 grains.
	Water, ...	16 ounces.
B.	Carbonate of potash, ...	1½ ounces.
	Water, ...	16 ounces.

Developer. — Equal parts of A and B.

EIKONOGEN DEVELOPER.

A. Sulphite of soda (crystals), ... 4 ounces.
Distilled water, ... 60 ounces.

Dissolve and add

Eikonogen, ... 1 ounce.
B. Carbonate of soda (crystals), . . . 3 ounces.
Distilled water, ... 20 ounces.

Developer.—3 parts of A and 1 part of B.

ONE SOLUTION EIKONOGEN DEVELOPER.

Sulphite of soda (crystals), ... 8 ounces.
Carbonate of soda (crystals), ... 3 ounces.
Distilled water, ... 80 ounces.
Eikonogen, ... 1 ounce.

SEED'S EIKONOGEN DEVELOPER.

A. Sulphite of soda (crystals), . . . 6 ounces.
(If granular sulphite of soda is used take only 3 ounces.)
Water (ice or distilled), ... 45 ounces.

First dissolve the above and then add

Eikonogen, ... 1 ounce.
B. Carbonate of potash, ... 1½ ounces.
Water (ice or distilled), ... 15 ounces.

Developer.—3 ounces of A and 1 ounce of B.

If more contrast is required, use more of A ; if less, more of B.

The developer can be used repeatedly by adding each time a little of each of fresh solutions A and B.

Notice the temperature of the room, as a slight variation in this respect causes a difference in the time it takes to develop. Temperature should be from 70 to 75 degrees, Fahr.

The developer may be used repeatedly, but will work slower when old (where no addition of fresh has been made). Fresh developer is better for short exposure, and the old, if the plate has been fully timed.

The quantity of eikonogen (A) must be according to the density of the negative wanted.

If the negative is too strong, use less. If not strong enough, more.

Wuestner's Eikonogen Developers.

FOR PORTRAITS AND LANDSCAPES.

No. 1.— Dissolve in 32 ounces distilled or ice water,
Sulphite of soda, C. P. (crystals), . 1 ounce.
Eikonogen, ... ½ ounce.

No. 2.— Dissolve in 32 ounces distilled or ice water,
Carbonate of potash, ... 3 ounces.

Developer.—Take equal parts of No. 1 and No. 2.

This developer may be used repeatedly, and will keep for months if preserved in tightly closed bottles. It is of great importance to use *only chemically pure sulphite of soda* (crystals). In order to dissolve the eikonogen quickly it is advisable to pulverize the same in a porcelain mortar.

FOR INSTANTANEOUS EXPOSURES.

Dissolve in 300 c. c. m. (or 10 ounces) distilled or ice water,
Sulphite of soda crystals, C. P., . 20 grammes (or ⅔ ounce).
Carbonate of potash, ... 10 grammes (or ⅓ ounce.)
And then add Eikonogen, ... 10 grammes (or ⅓ ounce).

Cramer's Eikonogen Developers.

NO. 1.

Distilled water, ... 40 ounces.
Sulphite of sodium crystals, ... 2 ounces.
Eikonogen, finely powdered, . . . 1 ounce.

Keep the solution in a well stoppered bottle.

NO. 2.

Water, ... 10 ounces.
Carbonate of potassium, ... 1 ounce.

NO. 3.

Water,	10 ounces.
Bromide of potassium,	1 ounce.

FOR USE.

Solution No. 1,	3 ounces.
Solution No. 2,	1 ounce.
Solution No. 3,	6 to 12 minims (or drops).

When the developer is quite new, it will be found necessary to add a little bromide solution (No. 3) in order to make it perfectly clear. The addition of old developer will answer the same purpose. The developer can be used repeatedly by occasionally adding more of solutions Nos. 1 and 2, omitting the bromide. It produces plenty of intensity by simply leaving the plate in it long enough. Any degree of softness can be obtained by diluting with more or less water, which is also recommended during hot weather and for under-exposures.

Over-exposed plates restrain by adding more solution No. 3.

A. P. SMITH'S EIKONOGEN DEVELOPER.

A.	Eikonogen (crystals),	120 grains.
	Water,	16 ounces.
	Glycerine,	2 drams.
	Sulphite of soda (crystals),	2 drams.
	Alcohol,	2 drams.
	Sulphite of soda (crystals),	3½ ounces.
B.	Water,	16 ounces.
	Carbonate of soda (crystals),	6 drams.
	Carbonate of potash,	3 drams.
	Yellow prussiate of potash,	1 dram.

Developer: A, 2½ ounces; B, 1 ounce. Restrain with bromide of potassium.

VANSANT'S CARBONATE OF LITHIUM DEVELOPER.

Distilled water,	1 ounce.
Tartrate of sodium and potassium,	25 grains.
Sulphite of sodium (crystals),	25 grains.
Carbonate of lithium,	1 grain.
Pyrogallol,	2 grains.

Dissolve in the order given. When the solution loses its energy after frequent use, it may be renewed by the addition of a few grains of pyro or lithium, as may be required.

CLEARING SOLUTIONS.

NO. 1.

Alum,	1 ounce.
Citric acid,	1 ounce.
Sulphite of iron,	3 ounces.
Water,	20 ounces.

NO. 2.

Alum,	1 ounce.
Citric acid,	$\frac{1}{4}$ ounce.
Water,	15 ounces.

NO. 3.

Saturated solution of white alum,	32 ounces.
Sulphuric acid,	$\frac{1}{2}$ ounce.

INTENSIFIERS.

No. 1.— Immerse the plate in a saturated solution of chloride of mercury ; wash well and flow with a dilute solution of ammonia.

No. 2.— Whiten the film in a saturated solution of chloride of mercury ; wash and blacken in a 1 to 5 solution of sulphite of sodium.

No. 3.— Saturated solution of bichloride of mercury, 10 ounces ; iodide of potassium, 10 drams. Dissolve the iodide

in ten ounces of water, and pour gradually into the mercury solution until the precipitate is nearly redissolved. Add 1 ounce of hyposulphite of soda.

NO. 4.

Bichloride of mercury,	10 grains.
Chloride of ammonium,	10 grains.
Water,	1 ounce.

Immerse the well washed negative in this solution until the film is whitened; then blacken in the following, after thorough washing:

Cyanide of potassium,	2 ounces.
Distilled water,	48 ounces.
Nitrate of silver,	1 ounce.
Distilled water,	6 ounces.

The silver solution is poured gradually into the cyanide, stirring with a glass rod. Allow the mixed solution to stand a few days before using.

REDUCING SOLUTIONS.

NO. 1.

Saturated solution of ferri-cyanide of potassium,	1 ounce.
Hyposulphite of soda solution, 1 to 5,	10 ounces.

NO. 2.

Potassium ferri-oxalate,	5 grains.
Hyposulphite of soda solution, 1 to 5,	1 ounce.

NO. 3.

Saturated solution of white alum,	32 ounces.
Sulphuric acid,	1 ounce.

NO. 4.

Perchloride of iron,	30 grains.
Citric acid,	60 grains.
Water,	16 ounces.

NOTE.— The negatives should be thoroughly washed, in all cases.

TABLE SHOWING COMPARATIVE VALUE OF ALKALINE CARBONATES IN DEVELOPERS.

O. G. MASON, *in the Photographic Times Annual.*

COMMERCIAL NAME.	Chemical Symbol.	Molecular Weight.	The Commercial Salt contains of the pure Salt about	100 parts of 36 per cent Acetic Acid Require for Saturation	Solubility in Water, approximate.
Soda, Caustic	NaOH	40	80 to 92%	26.66 prts of 90% Soda	1 part in 2
Sodium Carbonate, Carbonate of Soda, Sal Soda, Crystals,	$Na_2CO_3.10H_2O$	286	96 to 98%	89.38 " " 96% "	1 " 2
The same, anhydrous or in dry powder..	Na_2CO_3	106	About 98 to 99%	89.38 of 98 to 99% dry Sal Soda.	1 " 6
Sodium Bicarbonate, Bicarbonate of Soda, "Sesqui-carbonate of Soda,"	$NaHCO_3$	84	98 to 100%	50.91 of 99% Bicarb Soda.	1 " 12

Equal work is done by 80 parts of Caustic Soda, 286 parts of Sal Soda (crystals), 106 parts of Sal Soda (dry), 168 parts of Bicarbonate of Soda. These quantities must be increased to make up for any impurity contained in the sample being used; for this purpose the usual percentage of impurity given in the above table may be assumed for all ordinary photographic uses.

Potassa (Caustic Potash)	KOH	56	80 to 95%	37.33 parts of 90% Potassa.	1 part in 1
Potassium Carbonate Carbonate of Potassa, Sal Tartar, Saleratus,	$K_2CO_3.1\frac{1}{2}H_2O$	165	76 to 96% Usually about 81%	51.11 parts of 81% Carb. Potassa.	1 " 1
Potassium, Carbonate, dry	C_2CO_3	140	About 95%	122.74 parts of 100% Carb. Potassa.	1 " 1
Potassium Bicarbonate, Bicarbonate of Potassa,	$KHCO_3$	100	100%	60 parts of 100% Bicarb. Potassa.	1 " 4

Equal work is done by 112 parts Caustic Potassa, 165 parts (about) Carbonate Potassa, 200 parts of Bicarbonate Potassa. These quantities must be increased in proportion to impurities as noted in case of Soda. These two alkalies are interchangeable for doing the same amount of work when *pure*, and when the one named in a given formula cannot be obtained the table may assist in choosing a substitute of proper strength and solubility.

Dry or anhydrous Carbonate of Potassium is not usually found in the market.

IMPURITIES IN PHOTOGRAPHIC CHEMICALS AND TESTS FOR THEM.

G. M. Jones, *in the Photographic Times Annual.*

SUBSTANCE.	IMPURITIES POSSIBLY PRESENT.	TESTS.
Ammonia	Carbonic Acid	Renders lime-water milky.
	Dissolved solid matter	Residue left on evaporation.
	Chlorides	After acidulating with nitric acid, it gives a precipitate with silver nitrate, which, after washing, is readily soluble in ammonia, and re-precipitated by nitric acid.
	Sulphates	After acidulating with nitric acid, it gives a precipitate with barium nitrate.
	Lime	A white precipitate with oxalate of ammonium.
	Lead is often present, derived from the action upon flint glass bottles.	Black precipitate, with sulphuretted hydrogen.
Nitric Acid	Traces of sulphuric acid	After dilution it gives a precipitate with barium nitrate.
	Chlorides	After dilution it gives a precipitate with silver nitrate.
	Peroxide of nitrogen	The acid is yellow.
	Iodine may be present if the acid be prepared from sodium nitrate.	After dilution and cooling it gives a blue color with starch paste or mucilage.
Hydrochloric Acid	Free chlorine	Liberates iodine from solution of potassium iodide. See also chlorides, nitric acid.
	Sulphuric acid	As above for nitric acid.
	Perchloride of iron	Yellow color. Brown precipitate with ammonia added till it smells slightly.
Hydrochloric Acid	Arsenic	Marsh's test.
	Some yellow samples contain no iron, but an organic salt, and give an alkaline ash on ignition of the residue after evaporation.	Reinsh's test; a small piece of copper foil becomes coated on boiling in dilute acid.

SUBSTANCE.	IMPURITIES POSSIBLY PRESENT.	TESTS.
Sulphuric Acid	Bisulphate of potassium	Residue on evaporation.
	Sulphate of lead	Milkiness on dilution. May be completely freed from lead by diluting with three or four times as much water, and allowing to settle.
	When sold as pure, it invariably contains a trace of iron. Common acid is also liable to contain arsenic, selenium, thallium, and many other substances.	No easy test can be given, as the substances are so numerous; some of them volatile, and most require separation from the acid before detection.
	Organic matter, as a piece of straw in a carboy of acid.	Gives a brown color to the acid.
Acetic Acid	Water	Does not solidify when cooled to 17° C, (53° F).
	Sulphurous and hydrochloric acids.	White precipitate with silver nitrate.
	Aldehyde, or volatile tarry matter.	Blackens in the light after adding silver nitrate.
	Organic sulphuric acid	Smell of garlic.
Citric Acid	Tartaric acid	Strong solution of potassium acetate added to a strong solution of the acid will deposit white crystalline bitartrate.
Pyrogallic Acid	Metagallic acid	Black residue insoluble in water.
Silver Nitrate	Free nitric acid	Reddens litmus paper (neutral silver nitrate does not affect litmus).
Potassium Carbonate	Chlorides and sulphates	Same as for ammonia.
Potassium Iodide	Potassium Carbonate	A strong solution in alkaline to test paper.
	Sulphates and chlorides	Same as for ammonia.
	Potassium iodate	A pretty strong solution becomes yellow from liberation of iodine on addition of dilute sulphuric acid, or better, a strong solution of citric acid.
Potassium Bromide	Similar to potassium iodide	See potassium iodide.
Sodium Carbonate	Chlorides and Sulphates	Same as for ammonia.
Sodium Chloride	Chloride of calcium Chloride of magnesium	Oxalate of ammonium (after addition of a little acetic acid) gives a milkiness or precipitate, indicating calcium; filter this out, and add ammoni, chloride of ammonium, and phosphate of sodium (clear solutions). A precipitate indicates magnesium. Both the above cause dampness in wet weather.
	Sodium sulphate	As for sulphates in ammonia.

SUBSTANCE.	IMPURITIES POSSIBLY PRESENT.	TESTS.
Potassium Cyanide.... Potassium Hydrate	Potassium carbonate nearly always present.	Effervescence with dilute acids, giving off a gas carbonic anhydride, which renders lime water turbid.
Kaolin	Chalk	Effervescence with dilute acids.
Water	Sulphates and chlorides	Same as for ammonia.
	Calcium carbonate, temporary hardness.	Deposited by boiling.
	Ammonia, almost always present in distilled and rain water.	Test as for calcium chloride, see sodium chloride.
		Brown coloration, or precipitate with Nessler's re-agent.
Gelatine	Alum	Ash, sometimes as much as 10 per cent.
	Fatty matter	Separated by precipitation with alcohol. Dissolved out by ether or benzine, and left as a residue on evaporation of the solvent.
Ammonium Bromide...	Potassium bromide, or other non-volatile bodies.	Leaves a residue when heated.
	Ammonium chloride.	Same as for chlorides in ammonia.
Pyrogal ic Acid	Powdered glass	Left behind on solution.
Potassium Iodide	Potassium bromide	The crystals of bromide are usually more transparent than those of iodide, but no reliance can be placed on this.
Silver Nitrate	Potassium nitrate, sometimes present in the fused sticks, not in the crystals.	Will not yield the full quantity of chloride on precipitation with HCl. Gives a purple color to flame.
Calcium Chloride	Calcium hydrate	The clear filtered solution made with distilled water is alkaline to test paper, and gives a precipitate on breathing into it through a tube.
Pure (?) Chemicals generally.	Broken glass, bits of straw, wood, paper, etc.	These impurities either float or sink on the solution, and may easily be seen.

TABLES FOR THE CONVERSION OF GRAMS (OR CUBIC CENTIMETERS) INTO OUNCES AND GRAINS.

CONVERSION OF GRAMS INTO GRAINS.

Grams.	Grains.
1	15.43
2	30.86
3	46.29
4	61.73
5	77.16
6	92.59
7	108.03
8	123.46
9	138.89

CONVERSION OF GRAINS INTO GRAMS.

Grains.	Grams.
1	.0648
2	.1296
3	.1944
4	.2592
5	.3240
6	.3888
7	.4536
8	.5184
9	.5832

CONVERSION OF GRAMS INTO TROY OUNCES.

Grams.	Troy Ounces.
1	.03215
2	.06430
3	.09645
4	.12860
5	.16075
6	.19290
7	.22505
8	.25720
9	.28935

CONVERSION OF GRAMS INTO AVOIRDUPOIS OUNCES.

Grams.	Avoird's Ounces.
1	.03527
2	.07054
3	.10581
4	.14108
5	.17635
6	.21162
7	.24689
8	.28216
9	.31743

The above tables render the conversion of the weights in question a matter of great ease, the error introduced in the last decimal place being trivial.

The use of the tables will be best illustrated by an example. Supposing that it is desired to find the equivalent in grains of 324.51 grams, we proceed by breaking up this number into the following series of constituent parts, and finding the grain-equivalent of each part from the table:

Portions of original number.	Equivalents in grains.
300.00	4630.
20.00	308.6
4.00	61.73
.50	7.716
.01	.1543
	5008.2003

The required quantity is 5008.2 grains. The numbers taken from the table will, in most cases, require a change as regards the position of the decimal point; thus, to find the value of 300 grams, one refers to the table, and finds 46.30 given as the equivalent, and a mere shifting of the decimal point two places towards the right multiplies this by 100, or gives the required number. In a similar manner, by shifting the decimal place of 30.86 one place to the

right we obtain the value in grains of 20 grams; while the number 61.7 is taken from the table without alteration as the equivalent of 4 grams. For .50 the table number must have its point shifted on to the left, making it 7.716 instead of 77.16; and finally, the value of .01 is obtained by shifting the point of 15.43 two places to the left.

The above operations are, in actual practice, performed with considerable speed, the required equivalents being written down one after the other on a scrap of paper, and then added up.

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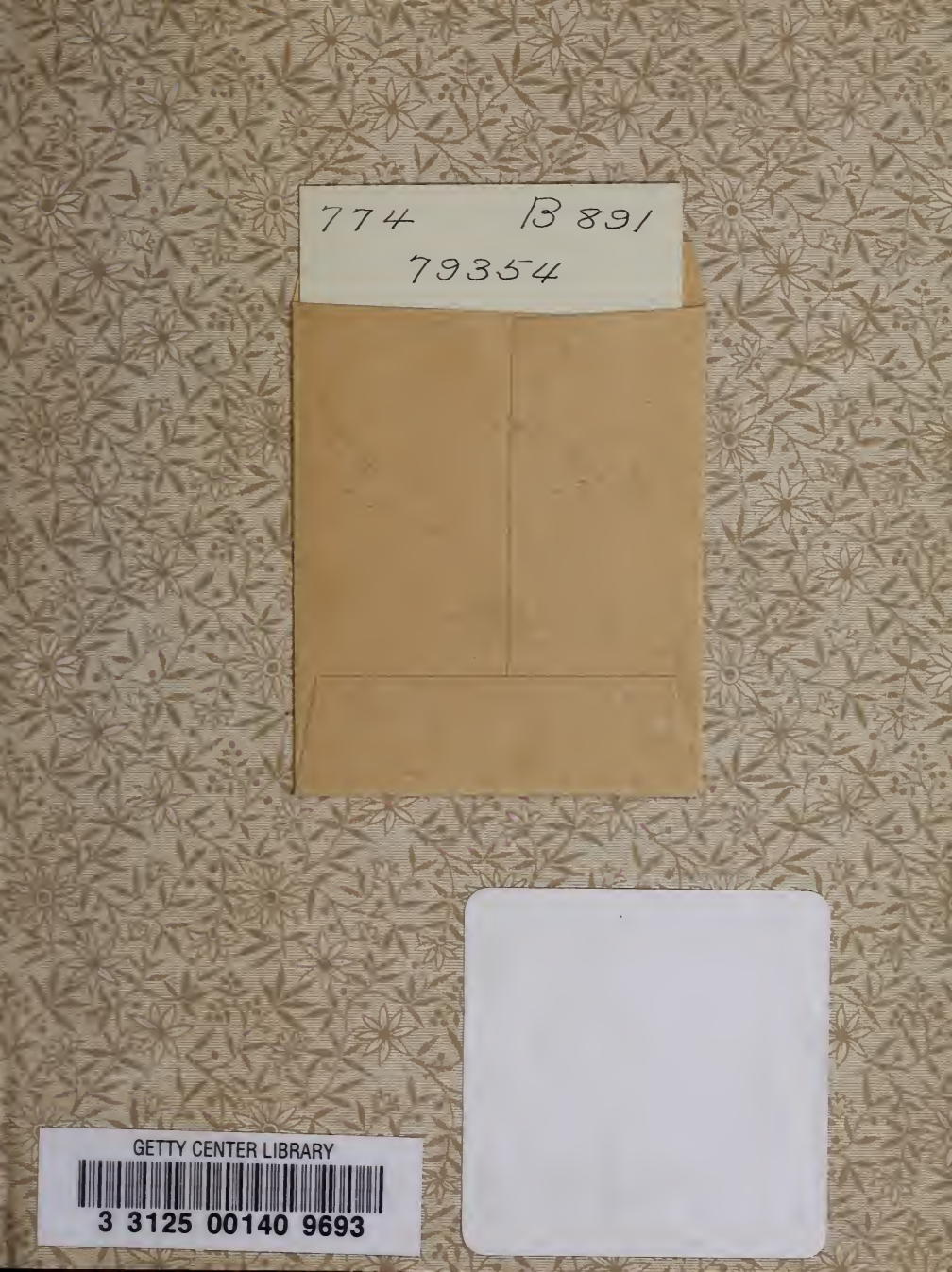
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